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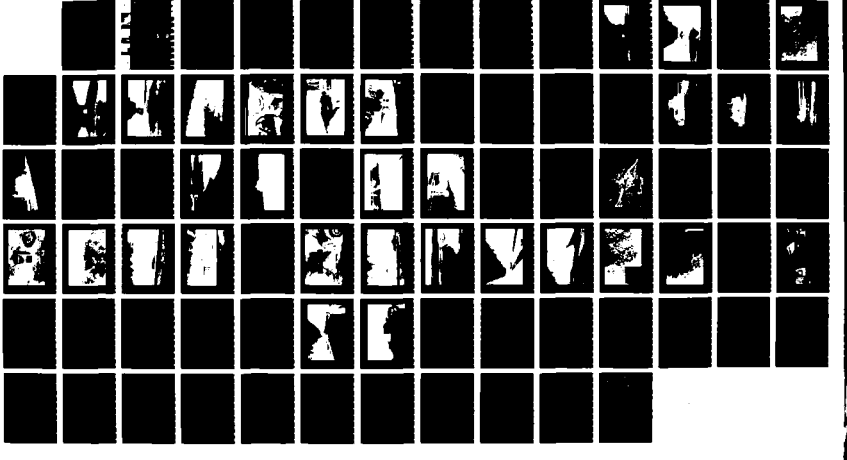

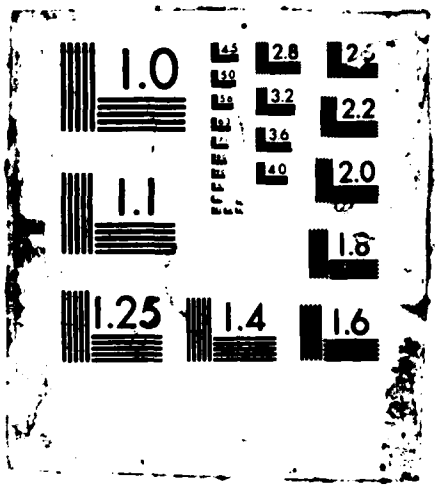
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US Army Corps of Engineers

DUSTPROOFING UNSURFACED TANK TRAILS GRAFENWOHR TRAINING AREA, FEDERAL REPUBLIC OF GERMANY JUNE 15-29, 1985

by

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GEOTECHNICAL LABORATORY

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Dust has been a long-time enemy of the military. Dust occurs wherever military equipment operates over dry unsurfaced terrain. The amount of dust realized is directly proportional to the types and numbers of military vehicles operating, the duration of the particular activity, and the weather (moisture) condition during the activity.

Dust occurs when small surface particles are scraped or rubbed away from the traveled surface by a vehicle tire or track and carried airborne by wind forces (in wet weather the same abraded particles are washed away in the form of mud). One vehicle crossing an open field will not usually produce an objectionable amount of dust. Objectionable large, blinding, fog-like clouds occur when many vehicles follow the same unsurfaced route.

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Perhaps the most familiar of these dust-producing routes is the gravel road. A good structural material for gravel roads is coarse aggregate with sufficient sand to fill the voids, and adequate clay to bind these materials. Abrasion of the small clay particles begins with the passage of the first vehicle. Gradually, as more and more vehicles pass over the roadway, sufficient small particles are displaced so that the larger particles become unstable. Ruts begin to form. Soon, maintenance will be required to reduce the severity and extent of rutting. If sufficient clay particles are not replaced to stabilize the larger particles, the time between succeeding maintenance periods will be reduced. Magnesium chloride ($MgCl_2$) is a good dust-control material that resists the abrasion of the small particles and provides a more stable condition over a longer time period. This report describes the successful demonstration of $MgCl_2$ dustproofing technology on tank trails at Grafenwohr Training Area, Federal Republic of Germany, and provides the user with instructions for the conduct of dust-control projects.

PREFACE

This study was sponsored by Office, Chief of Engineers (OCE), US Army, and monitored by Directorate of Research and Development, as an integral part of the O&MA Program, Facilities Investigations Studies Program, FY 85. The OCE Technical Monitor was Mr. R. W. Williams.

The study was conducted under the general supervision of Dr. W. F. Marcuson III, Chief, Geotechnical Laboratory (GL), and under the direct supervision of Mr. H. H. Ulery, Jr., Chief, Pavement Systems Division (PSD) GL; Mr. J. W. Hall, Jr., Chief, Engineering Investigation, Testing and Validation Group, PSD, GL; and Dr. E. R. Brown, Chief, Materials Research Center, PSD, GL. Field test support was provided by MAJ R. A. Hass, PSD, GL; Mr. A. L. Middleton, Information Products Division; and Ms. L. H. Garner, Ms. G. F. Traxler, and Ms. C. P. Purviance, Resource Management Office. This report was prepared by MAJ Hass.

Installation support was provided at Grafenwohr Training Area, Federal Republic of Germany, by LTC L. E. Oliver and Mr. J. Weber, Directorate of Engineering and Housing.

COL Allen F. Grum, USA, was the previous Director of WES. COL Dwayne G. Lee, CE, is the present Commander and Director. Dr. Robert W. Whalin is Technical Director.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
degrees (angle)	0.01745329	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins*
gallons (US liquid) per square yard	4.5273	cubic decimetres per square metre
gallons (US liquid)	3.785	litres
inches	2.54	centimetres
pounds (mass)	0.4535924	kilograms
square feet	0.09290304	square metres
square yards	0.8361274	square metres
tons (2,000 pounds, mass)	907.1847	kilograms

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: $C = (5/9)(F - 32)$. To obtain Kelvin (K) readings, use $K = (5/9)(F - 32) + 273.15$.

DUSTPROOFING UNSURFACED TANK TRAILS, GRAFENWOHR TRAINING AREA, FEDERAL REPUBLIC OF GERMANY JUNE 15-29, 1985

PART I: INTRODUCTION

Background

1. Engineers at the US Army Engineer Waterways Experiment Station (WES) were requested in 1983 by the Director of Research and Development, Office, Chief of Engineers, to demonstrate the procedures and techniques for dustproofing unsurfaced roads and areas on military installations.

2. WES has previously conducted intensive research, field experiments, and evaluations of hundreds of dust-control agents and palliatives along with numerous dustproofing techniques and procedures. The culmination of this research and development in the area of dustproofing is technology transfer and the assistance provided to installations through the Facilities Investigations Studies (FIS) Program.

Occurrence

3. Dust has been a long-time enemy of the Army, especially in a tactical scenario. It occurs when military equipment operates over dry, unsurfaced terrain. This dust occurs when the small surface particles of the soil are scraped or rubbed away from the travelled surface by vehicle tires and tracks or aircraft landing gear and prop wash and carried airborne by wind forces* (Figure 1). One vehicle crossing an open field will not usually produce an objectionable amount of dust; however, the large, blinding, fog-like clouds (Figure 2) occur when many vehicles follow the same unsurfaced route or when numerous Air Force aircraft sorties use the same unsurfaced airstrip. A good structural material for gravel roads and assault airstrips is a coarse aggregate with sufficient sand to fill the voids and adequate clay to bind these

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* Note: In wet weather, the same abraded particles are washed away in the form of mud.

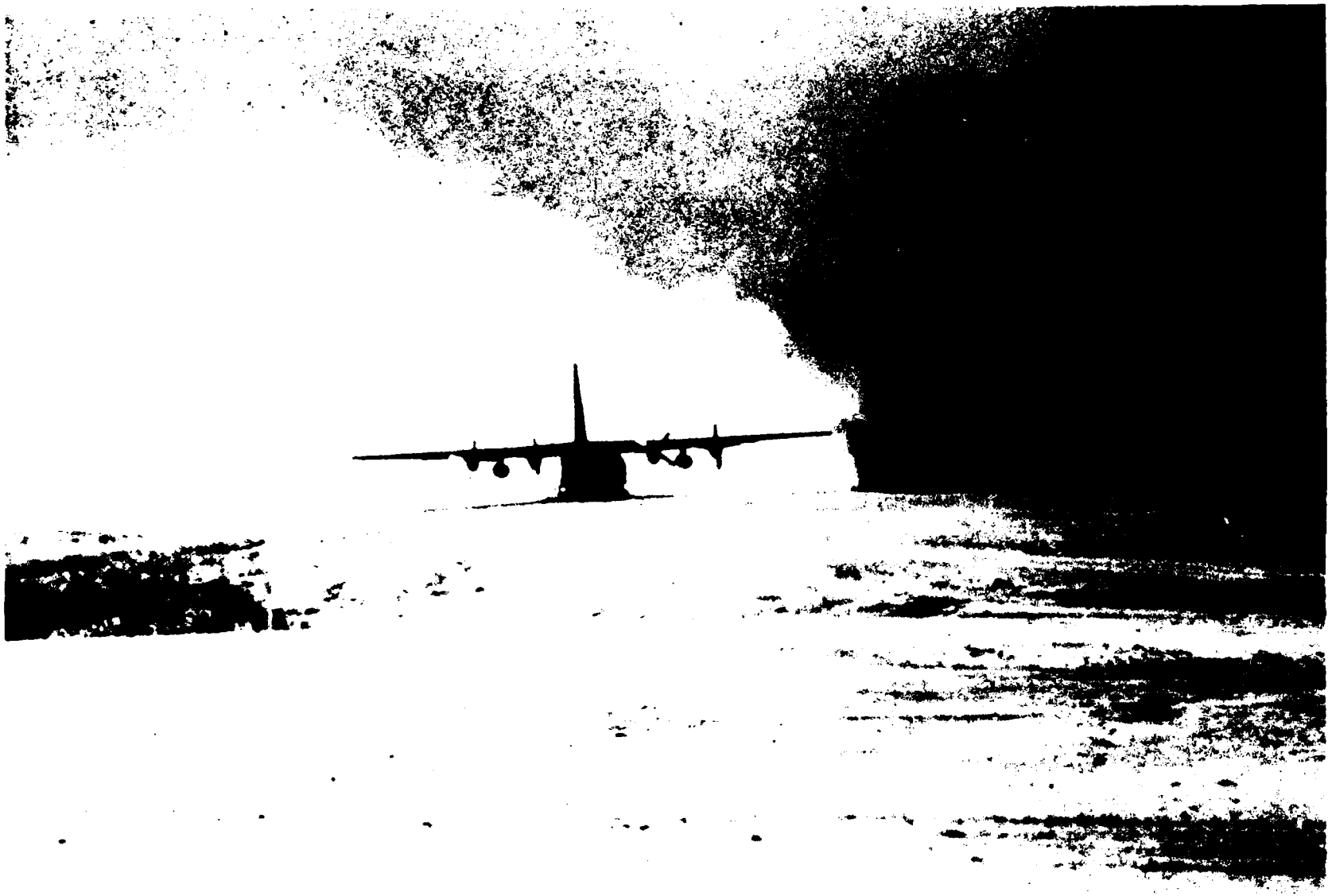

Figure 1. C-130 aircraft generating clouds of dust

Figure 2. Blinding, fog-like clouds of dust being generated by an M-1 tank

materials. Abrasion of the small clay soil particles begins with the passage of the first vehicle on the unsurfaced area. Gradually, as more and more vehicles or aircraft pass over the unsurfaced area, sufficient small soil particles are displaced so that the larger soil particles become unstable. Ruts, potholes, and washboard begin to form and soon maintenance will be required to reduce the severity and extent of deterioration. If sufficient clay soil particles are not replaced to stabilize the larger particles, the time between succeeding maintenance periods will be reduced. A good dust-control material resists the abrasion of the small soil particles, and a more stable condition is realized over a longer time period.

Plan of Demonstration

4. One of the dust-control techniques developed for dustproofing unsurfaced areas is the use of magnesium chloride ($MgCl_2$) as a dust palliative. This dustproofing technique was demonstrated by WES and the Directorate of Engineering and Housing (DEH), Grafenwohr Training Area (GTA), Federal Republic of Germany. This installation was selected based upon dust-control need, varying terrain and soil type, weather conditions, and location.

5. The $MgCl_2$ was selected for use at the installation because of its hygroscopic properties which bind the fine soil particles (dust) to the larger soil particles by absorbing moisture from the air. The surface produced is a tight, macadam-like surface when compacted (see Figure 3). The most effective use of $MgCl_2$ is its utilization on a cohesionless soil which is common on most military installations' unsurfaced tank trails and assault airstrips.

6. The demonstration site at Grafenwohr was selected, prepared, and treated. The site was bladed in selected areas to remove ruts, potholes, washboard, and all loose material and regravelled, prewet with water to reduce surface tension, and sprayed with the dust-control material $MgCl_2$. A Mercedes Unimog and a HydroSeeder with selected attachments were used to apply the $MgCl_2$.

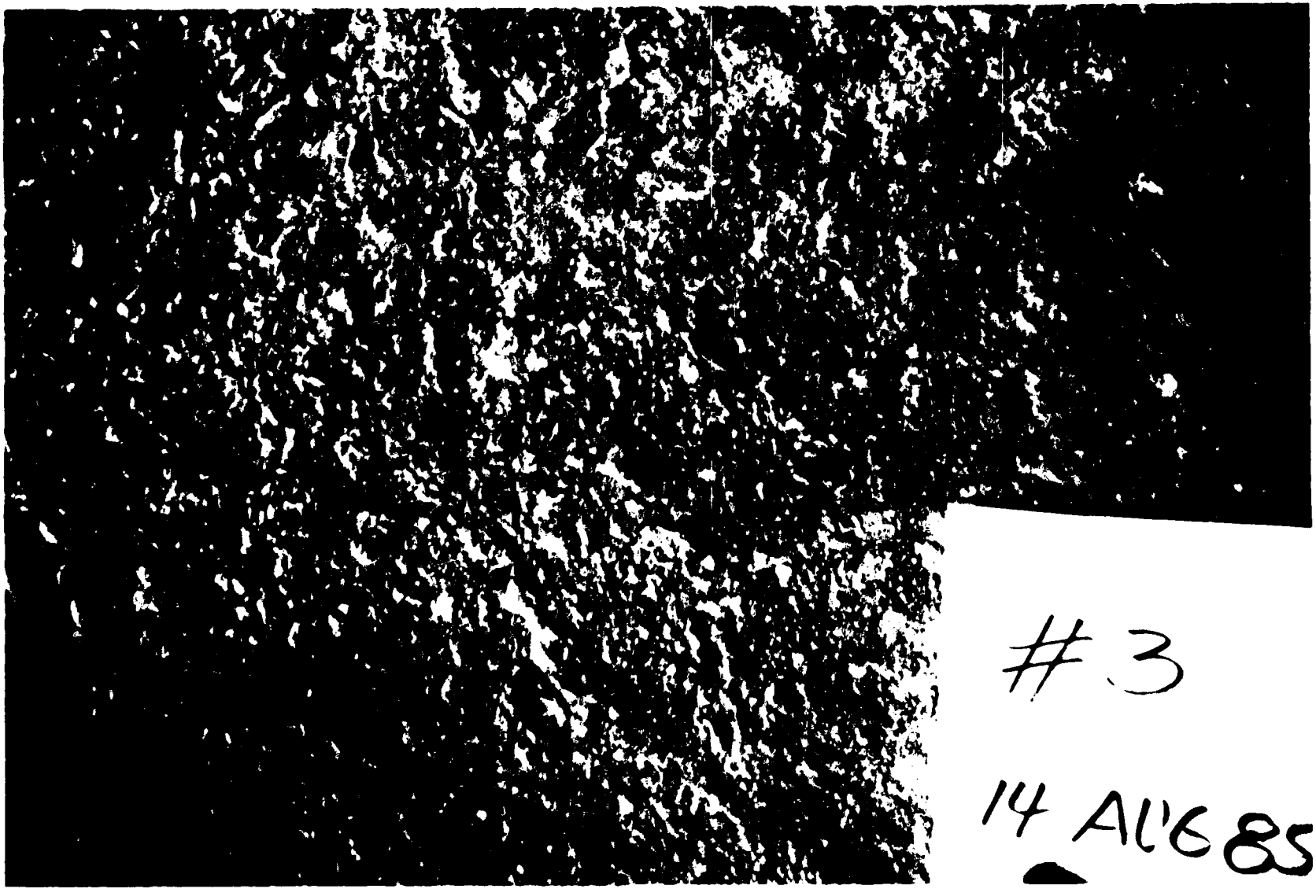

Figure 3. Tightly compacted gravel tank trail, Grafenwohr Training Area

PART II: DEMONSTRATION

Site Selection

7. The GTA was selected for the FIS demonstration based upon the amount of military traffic and the type of gravel roads. Also, site selection was based upon a dust-control need and adequate support available for the conduct of a dustproofing demonstration. The installation selected had an immediate need for dust control. Wheeled and tracked vehicles at GTA were producing blinding dust on the gravel tank trails (Figures 4-6). This dust was reducing visibility and intruding into vehicle cargo areas and engine compartments (Figures 7 and 8). The dust problem was a safety hazard for operating vehicles on the tank trails and a major nuisance factor for soldiers operating military vehicles. The dust was also billowing and blowing into small villages and hamlets adjacent to the tank trails which caused some civilian community relation problems for the military command in the area.

Coordination

8. Messrs. Josef Weber and Peter Kraemer coordinated the storage locations for the $MgCl_2$ material and provided the equipment. They also assigned installation personnel to the demonstration projects to conduct site preparation and prewetting operations. They also made local contacts when necessary to accomplish demonstration objectives. Firm dates for the demonstrations were arranged with Mr. Weber to avoid conflicts with training exercises and utilization of areas at the installations by major Army units.

Logistics

9. Delivery arrangements were made with the local German contractor for the $MgCl_2$ to be transported to the demonstration site. At GTA, the $MgCl_2$ was delivered in four railroad tanker cars (Figure 9) with the capability of holding approximately 13,700 gal* each. A Mercedes Unimog and a HydroSeeder with

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* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

Figure 4. Two-and-a-half ton truck generating blinding dust

Figure 5. Armored Personnel Carrier (APC) generating dust, reducing the visibility of the operator in the following vehicle

Figure 6. M-1 tank generating dust

Figure 7. Dusty engine compartment of an APC

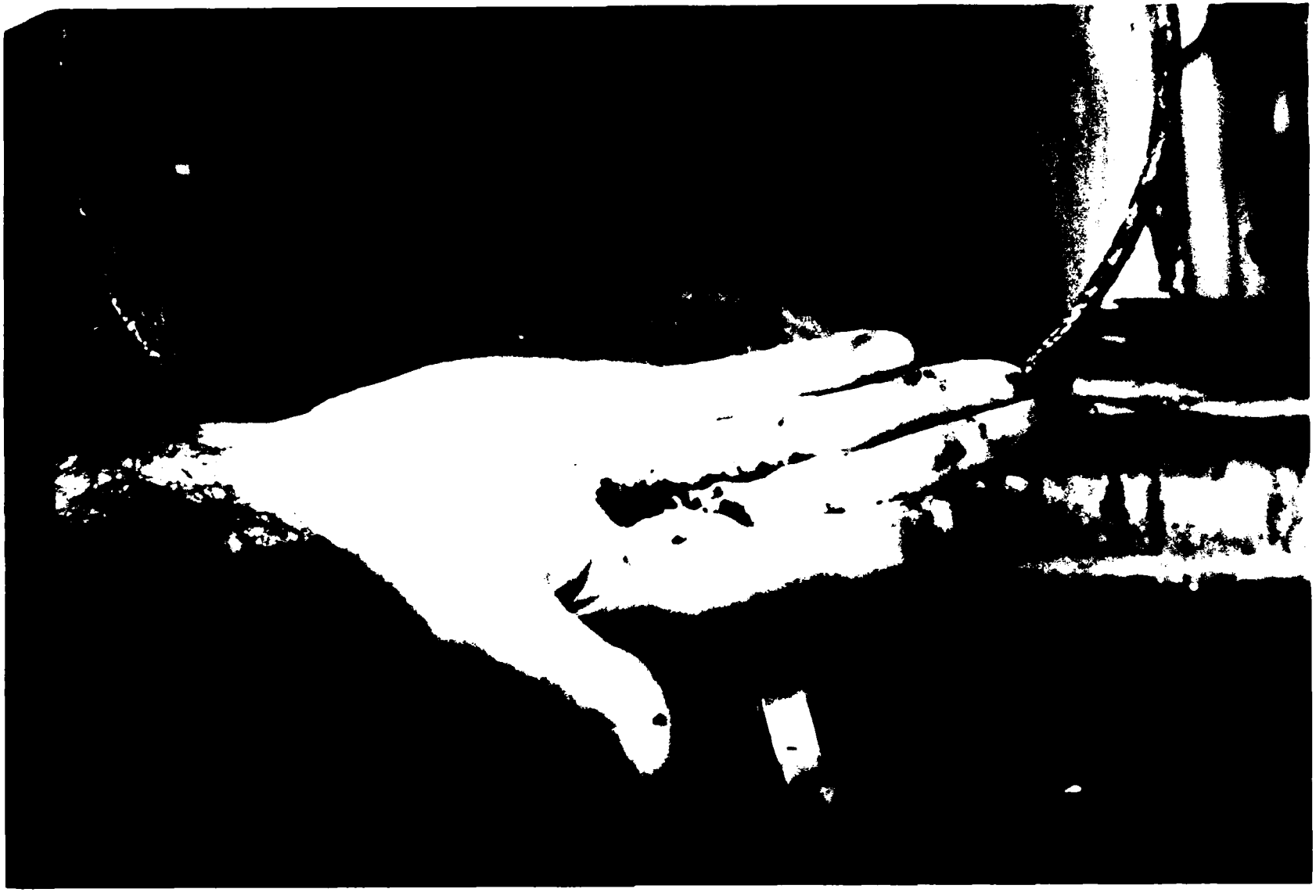

Figure 8. An APC air filter protective cover showing a high concentration of dust

Figure 9. Railroad tankers at the railhead loaded with $MgCl_2$

operators and laborers were scheduled for the designated demonstration time periods. Notification of the demonstration was sent to all Major Commands to inform individuals of the date, time, and location of the demonstration to allow Department of Defense (DOD) personnel to attend the demonstration. Handouts, demonstration plans, and briefings were prepared for any attending observers.

PART III: PROJECT PROCEDURE

Objective

10. The main objective of this demonstration was to familiarize the DEH in the US Army Europe (USAEUR) Command with this new technology by providing first-hand experience through observation, either by onsite or videotape viewing, of the dustproofing techniques and procedures.

Examples of Dust Problems

11. Dustproofing techniques should be considered for implementation in the following examples of dust-control problems occurring on military installations:

a. Dust generated by military vehicles operating on unsurfaced tank trails intrudes into housing areas or commercial activities that are adjacent to these tank trails.

b. Dust from tank trails impairs visibility on adjacent highways, roads, and streets.

c. Dust clouds generated by military vehicles operating on tank trails impair the visibility of military vehicle operators while driving on the tank trails.

d. Dust clouds generated by military aircraft operating on unsurfaced airstrips or helipads reduce the safe operations of the aircraft in those areas.

e. Dust intrudes into engines, engine compartments, air filtering systems, vehicle/aircraft turbines, and vehicle/aircraft cargo areas, thereby increasing wear and tear on the vehicles and aircraft.

f. Dust irritates the lungs and eyes of soldiers operating military vehicles.

g. Dust clouds generated by military aircraft or vehicle operations provide a recognizable signature to enemy forces in a tactical situation.

Construction Method Recommended

12. Inspect the area to be treated and blade selected areas to remove all loose material, ruts, potholes, and washboard and regravel, as necessary. Compact the bladed surface with a pneumatic rubber-tired roller, as necessary,

to achieve a hard surface that is not easily rutted by the using traffic. Spray water on the area to be treated. This prewetting operation is required to reduce surface tension, allow maximum penetration of the dust-control agent, and ensure a uniform application of the dust-control liquid over the applied area. The amount of water utilized during the prewetting operation is varied by surface conditions, soil type, and prevailing weather conditions, but the amount usually ranges between 0.03 and 0.30 gal/sq yd. After the prewetting operation, broom any water that has ponded before applying the dust-control material.

13. Apply the dust-control material as a liquid. Most dust-control liquids can be applied with a common asphalt distributor or even a gravity-fed water truck. Some liquids require agitation during transport and application to prevent segregation of the solution, and some require special equipment (Headquarters, Departments of the Army and Air Force 1974). Regardless of the method used for application, the application rate for the majority of dust-control liquids for the initial application should be 0.50 gal/sq yd. Higher application rates have a tendency to runoff, whereas lower application rates are not efficient or effective. Subsequent application rates for maintenance of previously treated areas can be as low as 0.25 gal/sq yd depending upon the degree of maintenance required (Styron, Hass, and Kelley 1985).

14. Ensure the spray bar is opened and closed at the proper locations and a 6- to 12-in. overlap is maintained on previously treated strips by close coordination between the distributor driver and the spray bar operator.

15. Observe closely the application of the dust-control material to the selected area. If the selected area is too dry from too little prewet water or evaporation of the water, the dust-control material will not penetrate the surface area and total coverage will not be achieved. Thus, adequate coating of the in situ material will not occur. The discontinuity of the dust-control material on the surface area and subsequent untreated areas formed are called fisheyes. Operations should be terminated whenever fisheyes occur and additional water should be applied before applying anymore dust-control material.

16. Allow the selected treated area to cure. Some dust-control materials require 4 hr or longer to cure before vehicle traffic is allowed to travel over the areas, or dust-control effectiveness can be sacrificed. The degree of effectiveness sacrificed is directly attributed to the actual cure time allowed versus the actual cure time necessary.

Materials Required

17. The dust-control material selected for the FIS demonstration was $MgCl_2$. This product was subjected to a series of tests at WES. These tests indicated that $MgCl_2$ had the potential for adequate dust control during a finite period when applied to gravel roads or areas having cohesionless type soil surfaces which are subjected to different types of vehicular traffic (Styron and Spivey 1982).

18. $MgCl_2$ is a commercial by-product of salt-mining operations. The brownish-yellow liquid brine solution is composed mainly of $MgCl_2$, the primary dust-control element (Appendix A). The brine solution is applied as received from the supplier with no dilution required. The application rate of this liquid is no more than 0.50 gal/sq yd. The brine solution is considered mildly corrosive, and vehicles or aircraft that come in contact with $MgCl_2$ treated areas should be washed during normal after-operation preventive maintenance periods. Personnel who come in contact with $MgCl_2$ should follow basic hygiene practices.

Equipment Required

19. A motor grader (Figure 10) is needed to blade the area to be treated, and a pneumatic rubber-tired roller (Figure 11) and a steel-wheeled roller (Figure 12) (for airstrip and helipad compaction) are needed to compact the bladed surface. A water truck is used to prewet the surface. An asphalt distributor (Figure 13) or a water truck capable of metering liquids can be used to apply the $MgCl_2$. $MgCl_2$ can be pumped through an asphalt distributor, but since it is not a natural lubricant, it will eventually bind the pump. Therefore, it is recommended that the pump on the asphalt distributor be modified for external lubrication, as indicated in Figure 14.

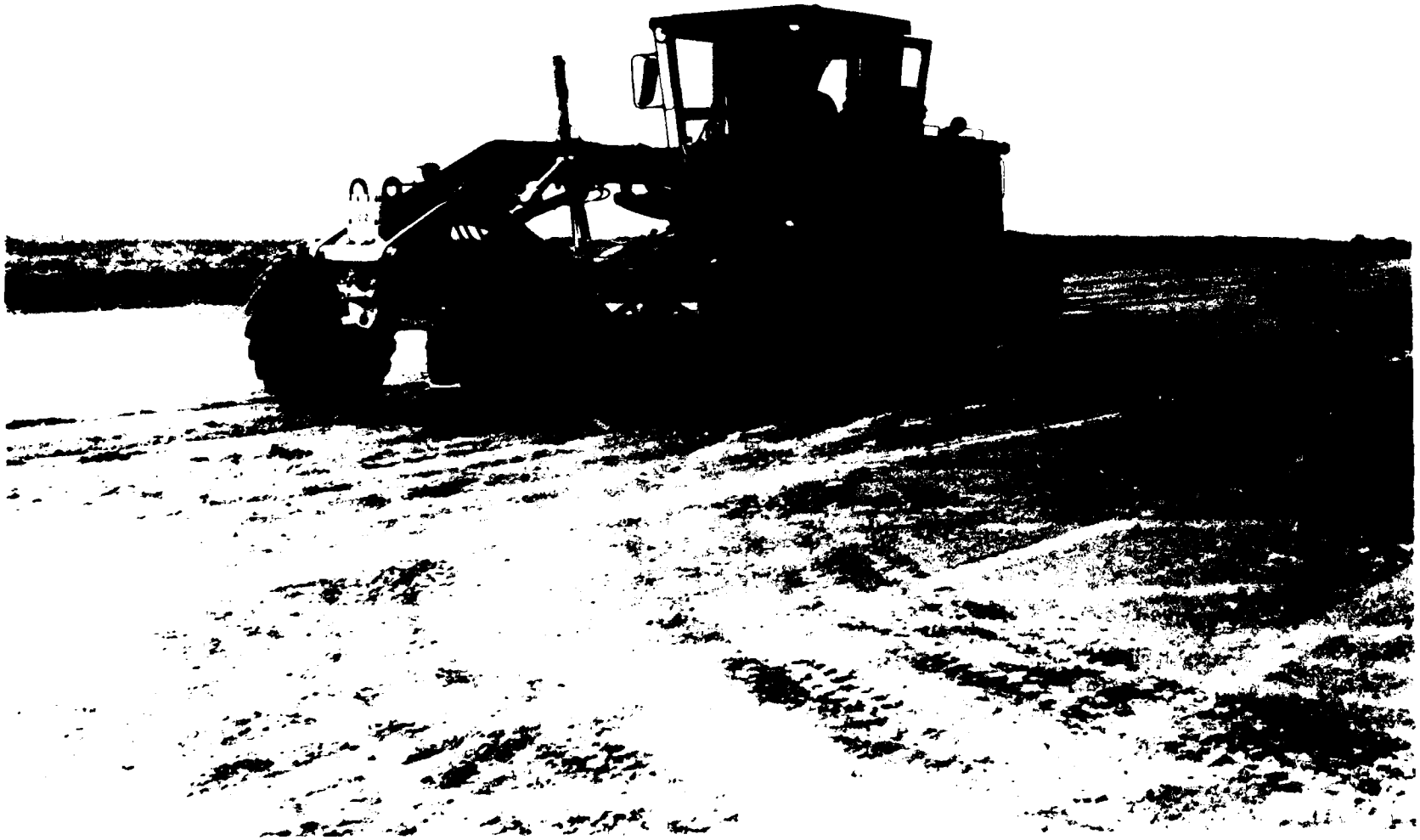

Figure 10. Motor grader blading away ruts and excess surface material

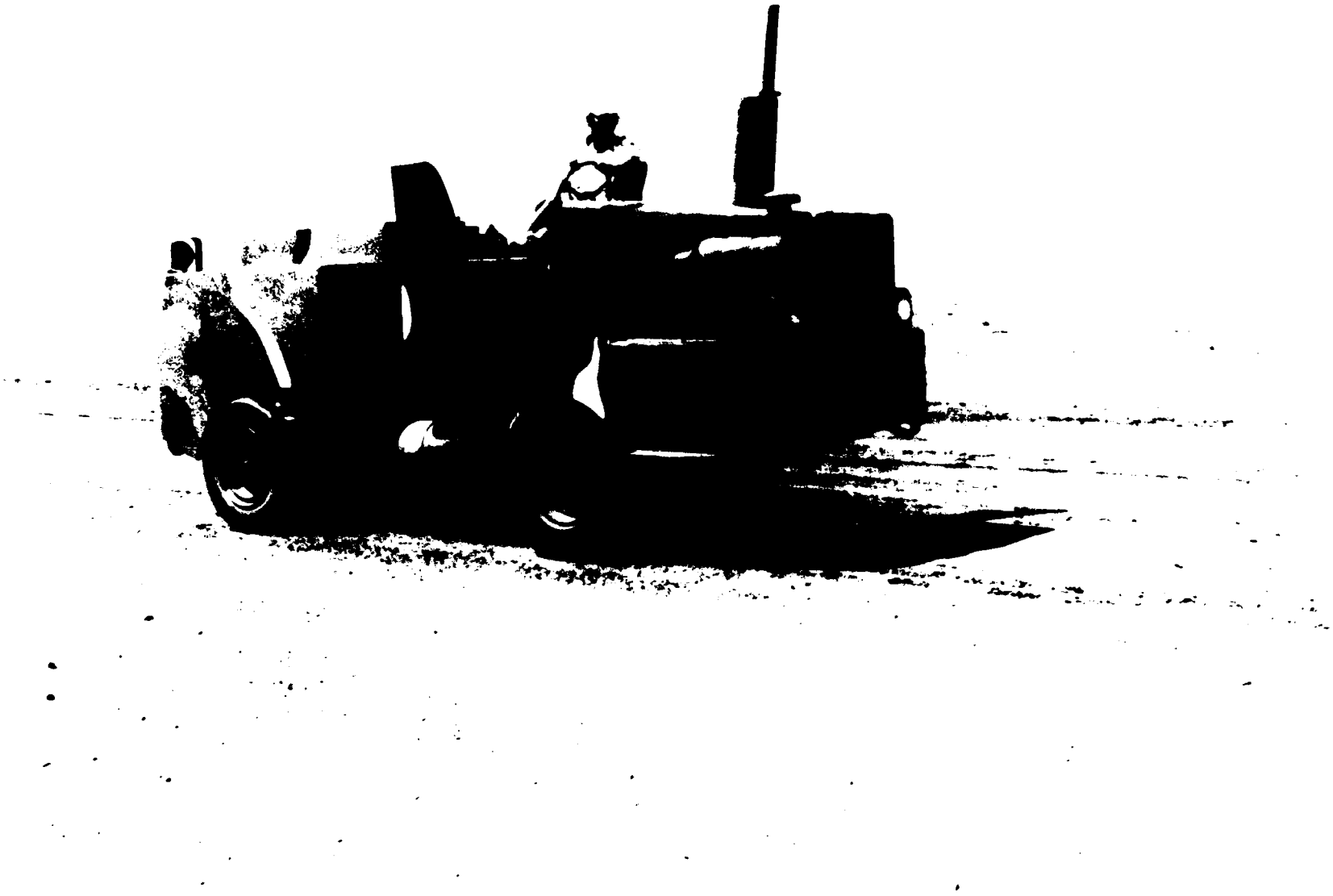

Figure 11. Pneumatic rubber-tired roller

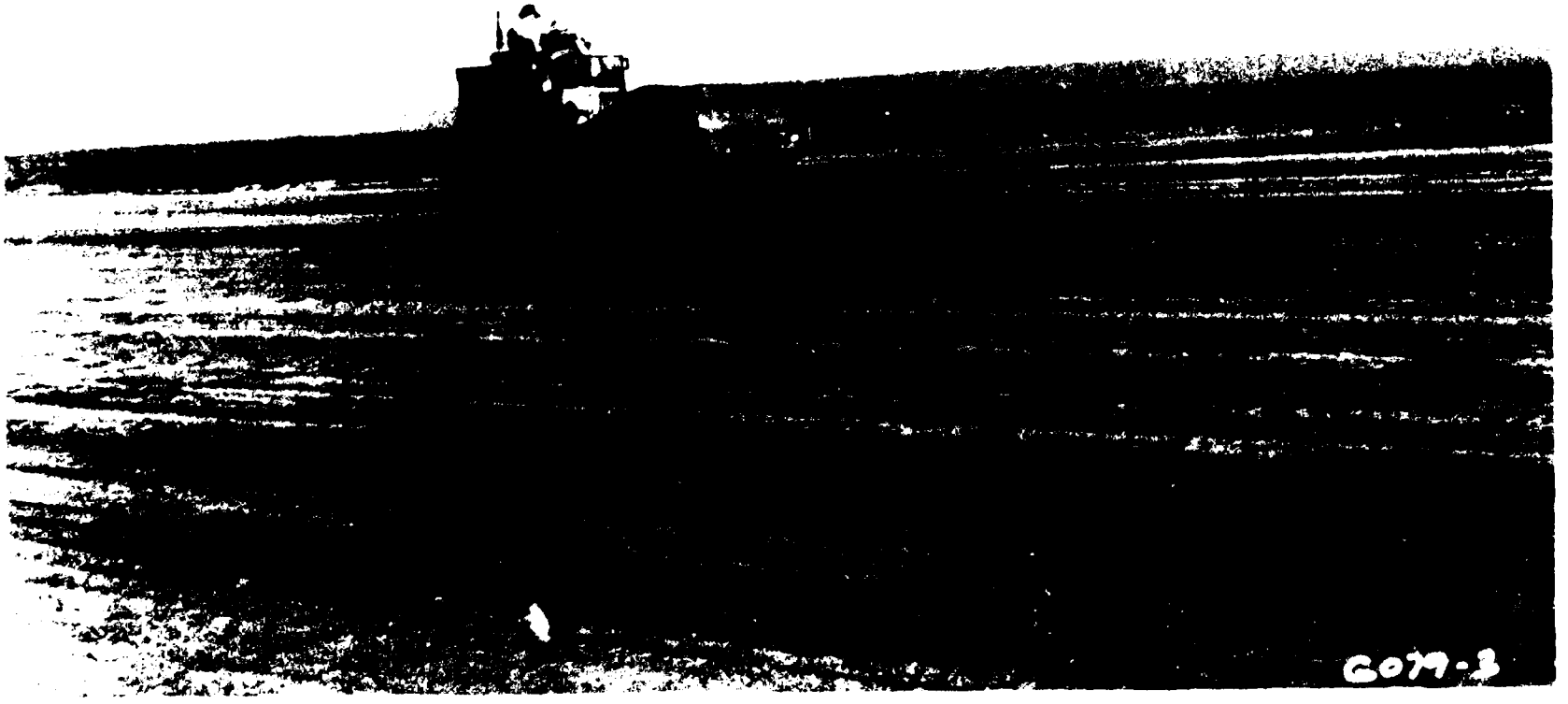

Figure 12. Steel-wheeled roller

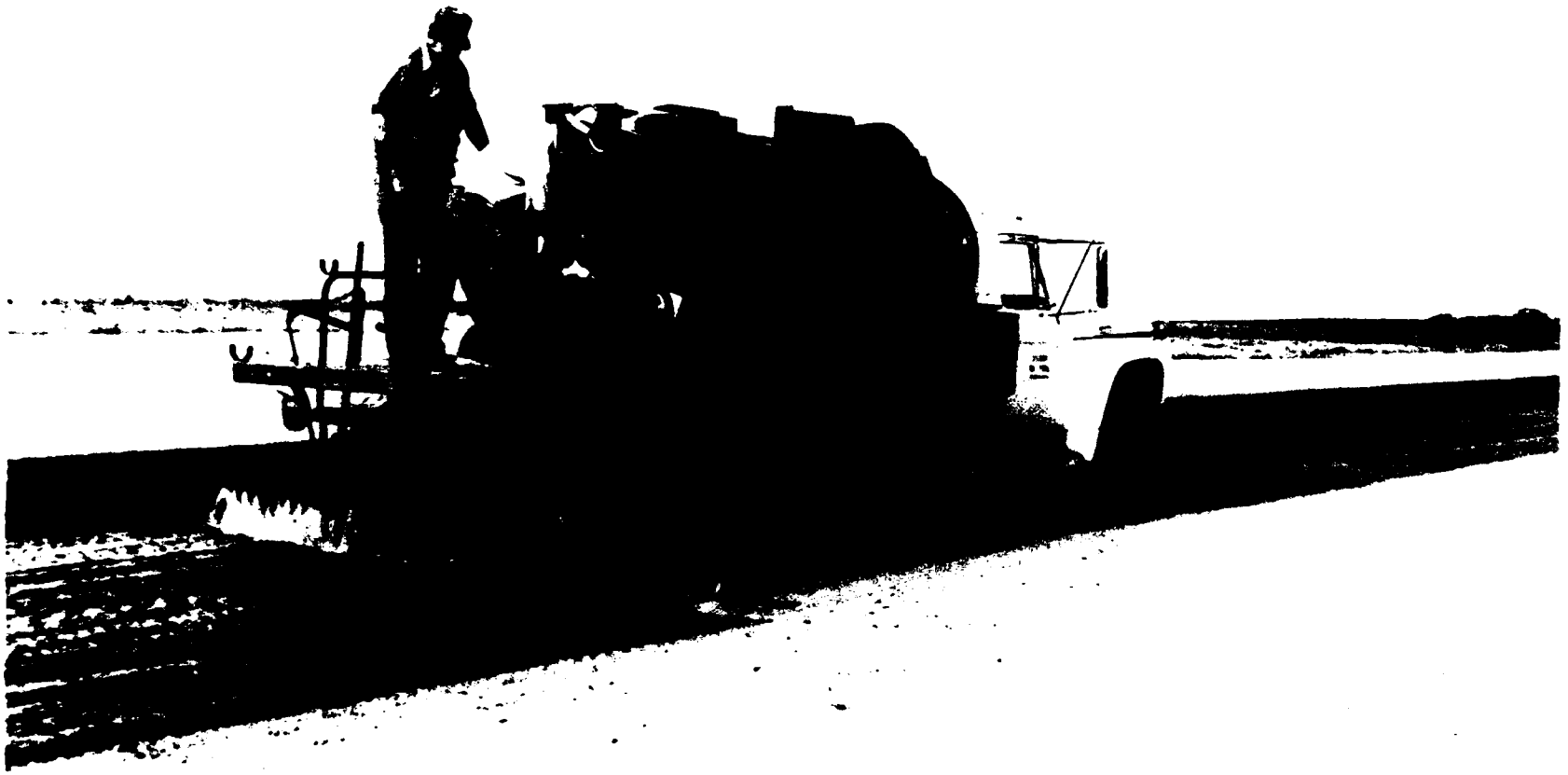

Figure 13. A 900-gal modified asphalt distributor

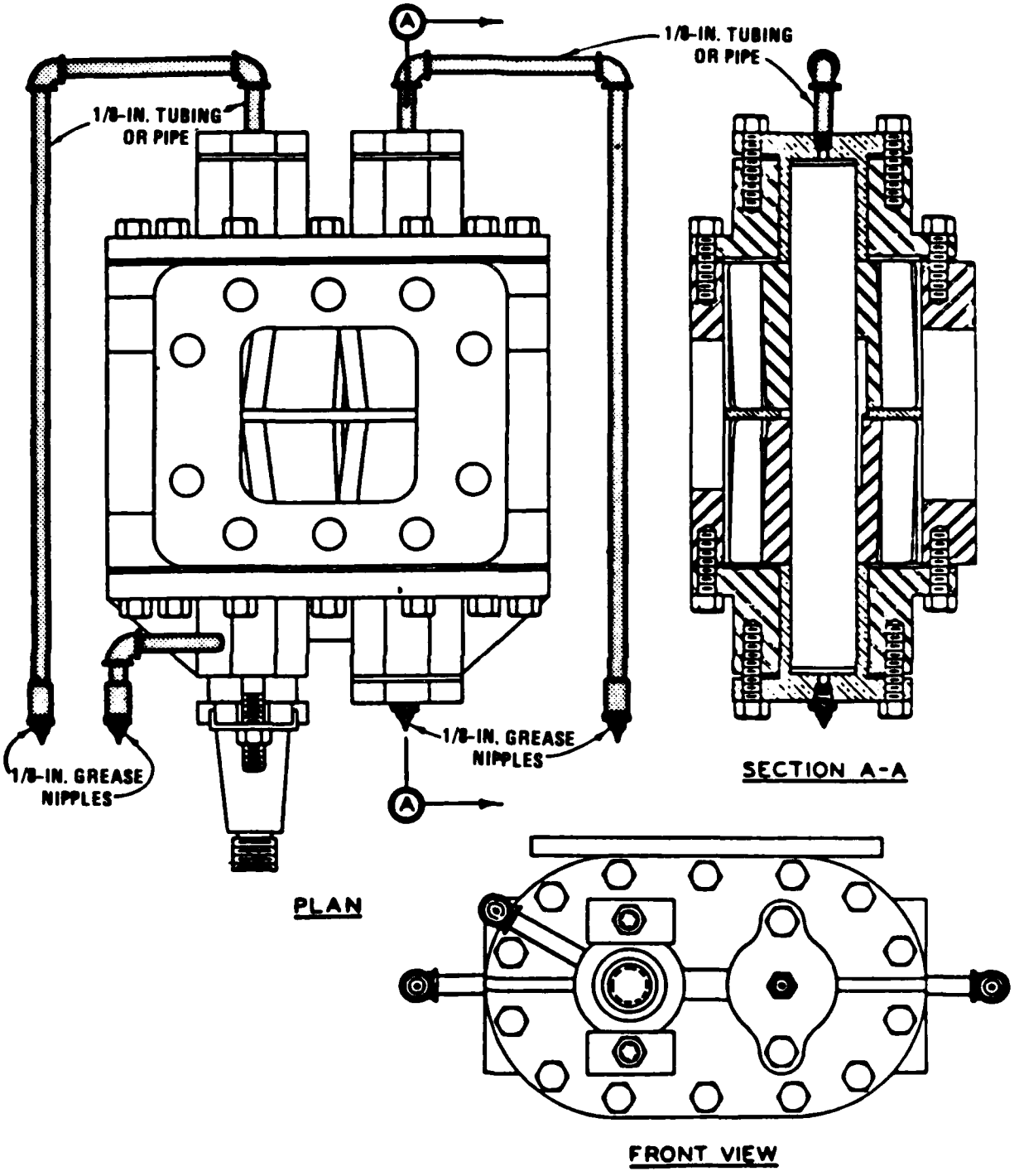

Figure 14. Modification to the positive displacement pump on the asphalt distributor

Personnel Required

20. Experienced operators are required for the motor grader, pneumatic rubber-tired roller, steel-wheeled roller (if required), water truck, and asphalt distributor. A civil engineer or engineering technician familiar with dust-control operations and an equipment foreman should be present when the dust-control material is being placed.

Recommended Procedure for Dustproofing with $MgCl_2$

21. The following guidance is the recommended procedure for dustproofing a selected area with $MgCl_2$:

a. Planning:

(1) Determine the area to be treated (square yards).

(2) Order enough $MgCl_2$ for an initial treatment of no more than 0.50 gal/sq yd but not less than 0.42 gal/sq yd and plan for a follow-up maintenance application of approximately 0.25 to 0.30 gal/sq yd after 8 to 12 months service life.

(3) Plan the project so that equipment and personnel are available to accomplish the preparation and application procedures in an orderly step-by-step process.

(4) Ensure storage facilities and/or a storage area is designated near the project site for the dust-control material.

b. Equipment and personnel:

(1) Necessary equipment:

(a) Standard motor grader to blade the surface of the selected area.

(b) A 5,000-gal water truck (Figure 15) with displacement pump to prewet the selected area. A smaller capacity water truck (Figure 16) can be used; however, it should have a capacity approximately twice that of the vehicle used to apply the $MgCl_2$.

(c) A pneumatic rubber-tired roller for compacting the selected area before the prewetting operation and after application of the $MgCl_2$ (if necessary).

(d) A modified asphalt distributor or a water truck capable of metered application of the $MgCl_2$.

(e) Plumbing attachments consisting of a 90- or 45-deg pipe collar which must fit a threaded pipe 4.25 in. in diameter on the bottom of the tank car and the

Figure 15. Commercial 5,000-gal water truck

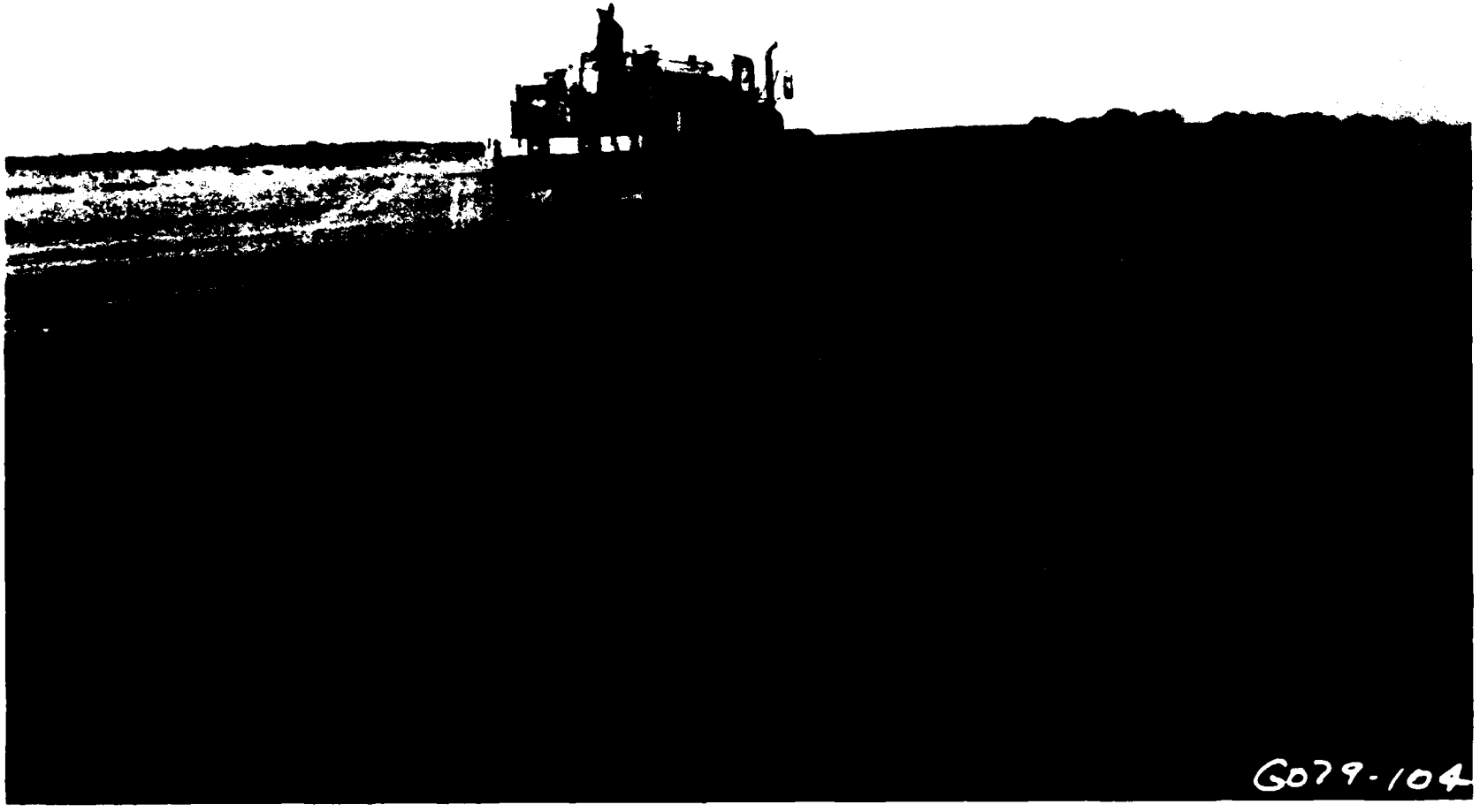

Figure 16. Military water truck with a 1,000-gal capacity

opposite end to fit the 3-in. flexible metal hose on the modified asphalt distributor (see Figure 17). Also, pipe fittings consisting of a 2-in. threaded nipple connected to the bottom of the tank car, a 2- or 3-in. bushing, and a 3-in. elbow which are all connected so that the 3-in. flexible metal hose from the modified asphalt distributor can be attached (see Figure 18).

(f) A steel-wheeled roller to provide a smooth, tight surface (for airstrip and helipads only).

(2) Necessary personnel:

(a) Civil engineer or civil engineering technician -- one (1).

(b) Onsite foreman -- one (1).

(c) Water truck driver and pump operator -- two (2).

(d) Motor grader operator -- one (1).

(e) Pneumatic rubber-tired roller operator -- one (1).

(f) Modified asphalt distributor operator and pump/spray bar operator -- two (2).

(g) Steel-wheeled roller operator (if required) -- one (1).

(h) Total personnel -- nine (9).

c. Site preparation:

(1) Blade away all ruts, potholes, washboard, and loose excess surface material to expose a hard surface and regravel, as necessary.

(2) Compact the bladed surface, as necessary, with a pneumatic rubber-tired roller to ensure a hard surface so as to prevent rutting caused by using traffic.

(3) Prewet the selected area with the water truck to reduce surface tension and increase the $MgCl_2$ penetration. Recommended application rate for the prewetting operation is between 0.03 and 0.30 gal/sq yd (application rate is dependent upon temperature and evaporation rate).*

d. Material application:

(1) Spray the $MgCl_2$ with a modified asphalt distributor or apply the $MgCl_2$ with a water truck capable of metering liquids at an application rate of between 0.10 and 0.50 gal/sq yd. A 6- to 12-in. overlap of treated strips is required to ensure that a uniform application is maintained on the treated area.

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* Note: The surface to be treated should be damp when $MgCl_2$ is applied. Puddles or ponded water should be swept or broomed away.

Figure 17. Plumbing attachments with the 45-deg pipe collar

Figure 18. Pipe fittings connected with the flexible metal hose

(2) Again, compact the treated area with a pneumatic rubber-tired roller to ensure the stability of the smaller particles. A curing period of at least 24 hr should be observed prior to compaction (only for airstrips and helipads). Four to six passes of the roller are all that is required. Rolling should be halted or postponed for a period of approximately 2 to 4 hr if the pneumatic rubber tires pick up too much soil particles from the treated surface or cause ruts to form. Military vehicles can be allowed to traffic the treated tank trails immediately after the $MgCl_2$ is applied; however, the effectiveness and efficiency of the $MgCl_2$ may be reduced in the long term.

(3) Compact the treated area with a steel-wheeled roller in the nonvibratory mode following the pneumatic rubber-tired roller. Two to four passes are all that is required to provide a smooth, hard surface. This step is needed for only airstrips and helipads.

e. Maintenance:

(1) Following periods of low rainfall or low humidity (humidity less than 30 percent), the hygroscopic properties of the $MgCl_2$ are rendered ineffective or dormant and dust will appear again. The $MgCl_2$ can be reactivated with an application of plain water at approximately 0.10 to 0.20 gal/sq yd. Periodic watering should be repeated as long as the dry period continues and whenever it occurs.

(2) Blading will be substantially reduced. If minor rutting occurs, spraying the area with a light application of water will assist the $MgCl_2$ in binding the small and large soil particles together again. Only blade the treated area if substantial rutting occurs.

(3) $MgCl_2$ will eventually leach from the treated area with continued exposure to weather extremes. A second application of $MgCl_2$ should be planned and anticipated following 8 to 12 months of service. The second application procedure is the same as the first, except $MgCl_2$ is applied at the lower rate of 0.25 to 0.30 gal/sq yd.

f. Safety:

(1) Apply local and Federal safety regulations.

(2) Wash military vehicles and aircraft that traffic treated areas. $MgCl_2$ is a mildly corrosive material.

(3) Practice normal hygiene if the $MgCl_2$ comes in contact with skin or clothes of personnel.

(4) Read the manufacturers' application recommendations and safety labels.

PART IV: CONDUCT OF DEMONSTRATION

22. Initial coordination of the demonstration began in February 1984 with the Chief, Building and Grounds Division, Office of the Deputy Chief of Staff, USAEUR. The GTA site was selected by the DEH, Headquarters, Seventh Army Training Command (7^{th}ATC). The actual installation site was selected by the Chief, Environmental Division, DEH, 7^{th}ATC, and the Chief, Buildings and Grounds Division, DEH, GTA. The DEH, GTA, was responsible for the project site preparation, prewetting operations, application procedures, equipment, personnel, and storage of the $MgCl_2$. The DEH, 7^{th}ATC, was responsible for funding the project, ordering the $MgCl_2$, and monitoring the environmental impact of $MgCl_2$. WES was responsible for conducting environmental literature research, monitoring the actual application of the $MgCl_2$, and documenting the project.

23. The GTA demonstration was conducted during the period 15 to 29 June 1985. The area to be treated was selected by the DEH, 7^{th}ATC, and the demonstration project plan was written by WES.

24. The area treated (see Figure 19) was a portion of tank trail approximately 4.8 km long and 3 m wide. The demonstration site was divided into two separate sections as wearing surfaces -- one section with basalt gravel and the other with limestone gravel. Figures 20 and 21 indicate the gradations of the gravel in the demonstration site.

25. The basis for selection of the area at the GTA was that the tank trail received extremely heavy mechanized and wheeled vehicle traffic year-round (equivalent to over 13 Division's worth of vehicles per year). The dust generated by this amount of traffic was a major maintenance problem, safety hazard, and nuisance to soldiers, in addition to causing poor community relations with the local German villagers who lived adjacent to the GTA tank trails.

26. Approximately 55,000 gal of $MgCl_2$ was purchased for this project, of which half would be used on the project site and the other half stored until it could be placed on a tank-firing course. The $MgCl_2$ was purchased from a local German contractor. Temporary storage of the $MgCl_2$ was in the railroad tank cars in which the material was transported to GTA.

27. Prior to the start of the demonstration, a literature review for laboratory testing of the $MgCl_2$ was conducted by the US Army Medical

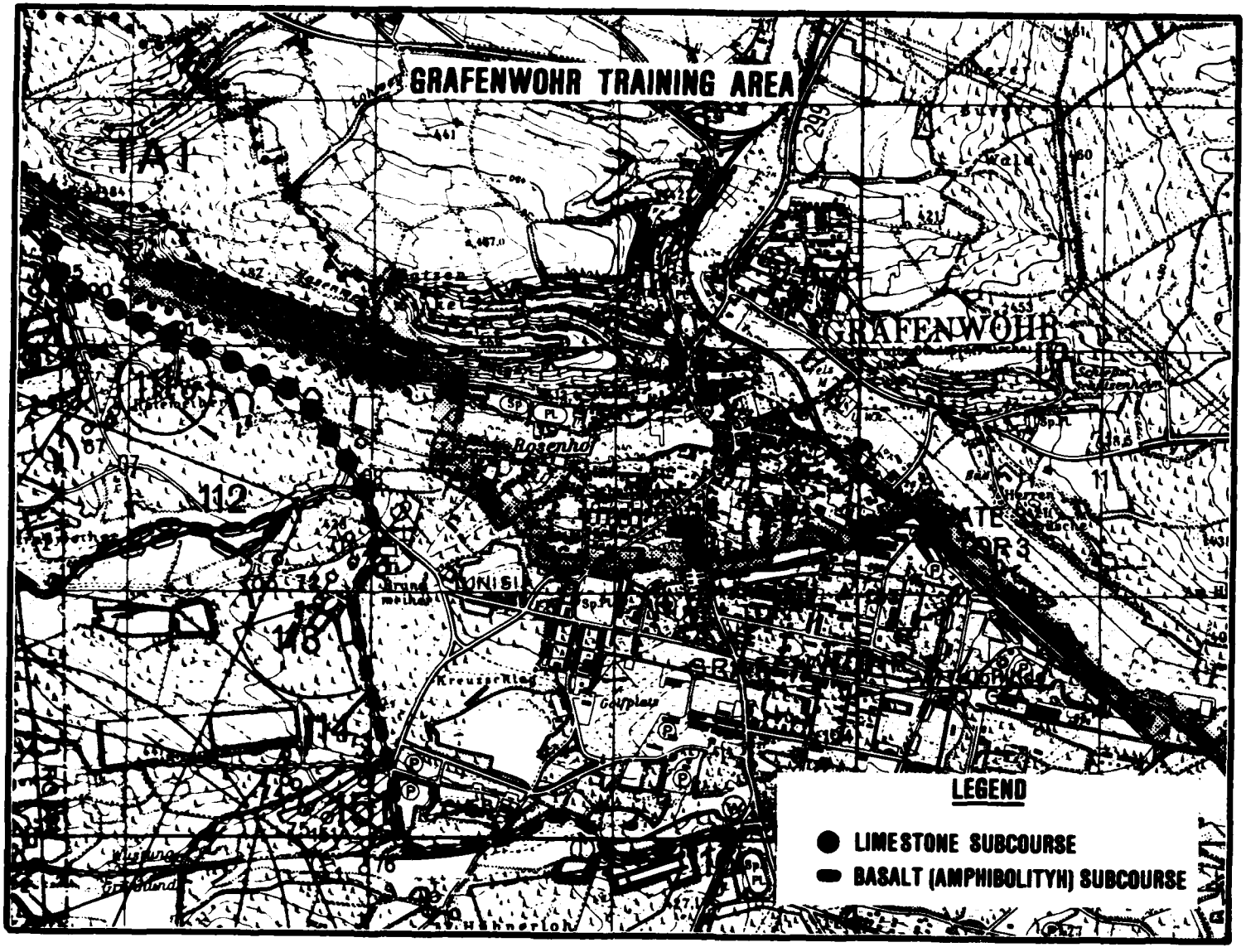

Figure 19. Grafenwohr Training Area, demonstration site

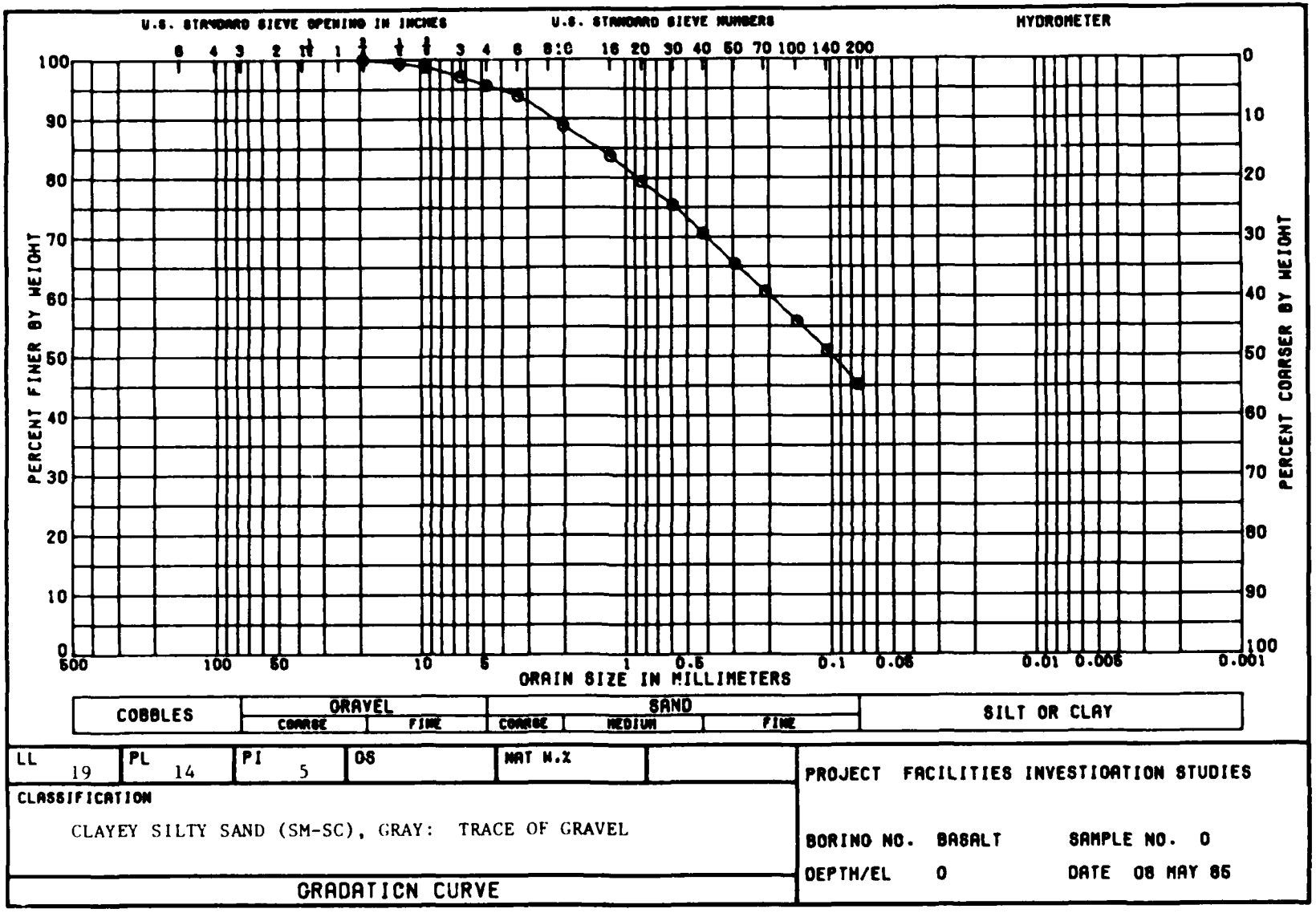

Figure 20. Gradation, basalt-gravel section

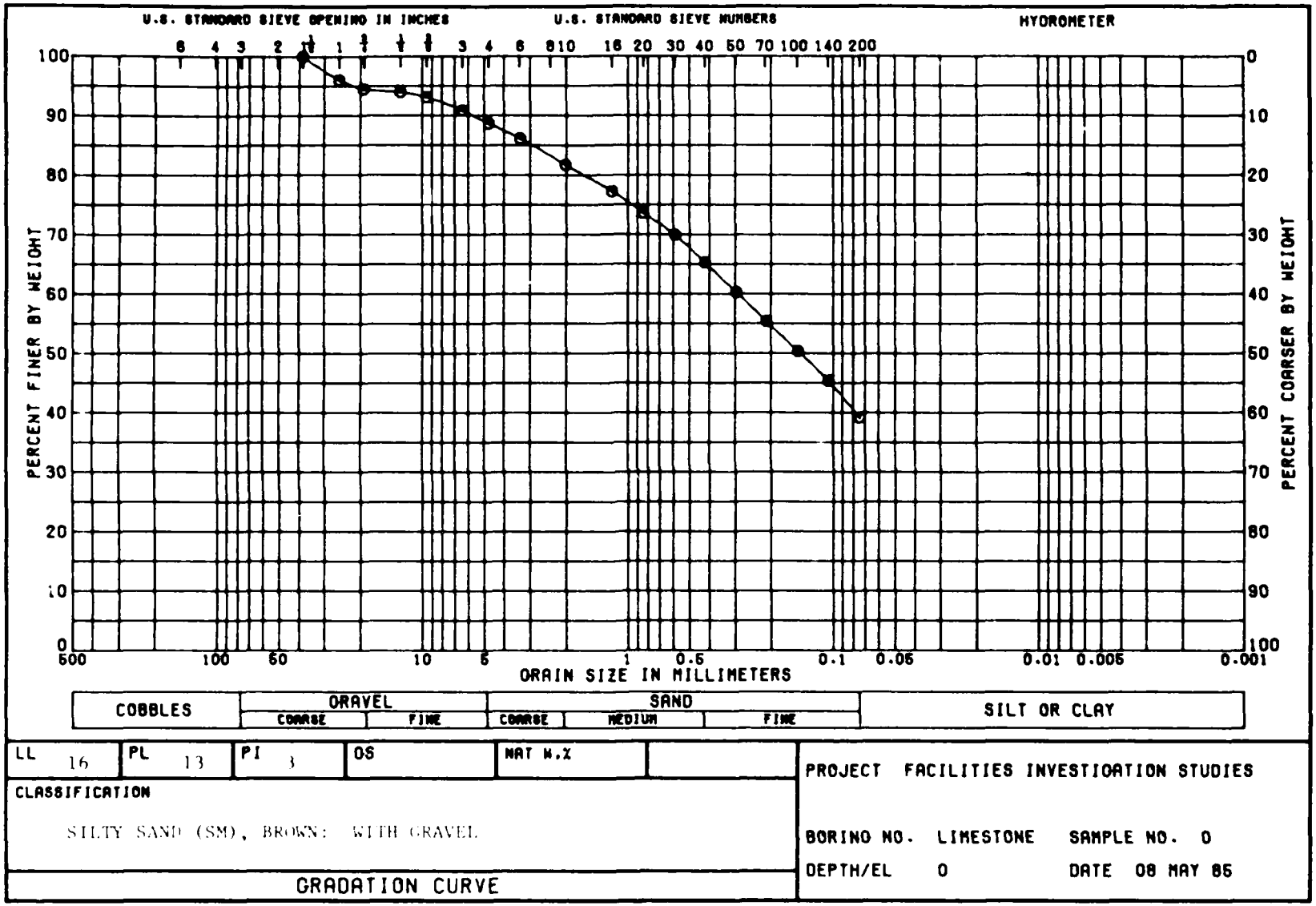

Figure 21. Gradation, limestone-gravel section

Bioengineering Research and Development Laboratory, Fort Detrick, Md. -- the results of which are shown in Appendix A of this report. Also, a complete literature review of environmental studies of $MgCl_2$ was conducted by WES. All pertinent documents were forwarded to the DEH, 7^{th}ATC, for coordination of the demonstration with the local German Government agencies. The local German Government Water Control Board was requested to approve and participate in the dustproofing demonstration. The Water Control Board approved the demonstration and agreed to participate by monitoring the stream runoff in the project site area for increases in salt ions in the water (Figures 22 and 23) and by rendering a report on their findings (Appendix B).

28. Prior to the site preparation, a Mercedes Unimog and a HydroSeeder which would be used to apply the $MgCl_2$ were checked thoroughly to ensure all working mechanisms functioned. The inspection included the following:

a. The spray bar and nozzles were checked for any debris which could have caused clogging during the spraying operation.

b. The pumps were checked for proper operation in filling the distributor tanks and for proper lubrication.

c. A test run was accomplished with water to check pump controls and speed to ensure the proper application rate could be achieved.

29. The demonstration site was inspected, and any areas that were in need of repair were prepared for treatment by first blading the area using a motor grader. This blading operation removed ruts, potholes, washboard, and loose excess material -- then the area was regravelled. The use of a pneumatic rubber-tired roller was not required because the high volume of expected military traffic would accomplish the compaction needed.

30. A 1,000-gal military water truck was used initially to prewet the selected area. However, a light intermittent rain occurred throughout the demonstration time period which deleted the need for a prewetting operation. This light rain maintained a damp surface on the gravel tank trail which reduced surface tension and increased the $MgCl_2$ penetration and coating of the gravel and fine soil particles.

31. The Mercedes Unimog with a distributor tank capacity of 528 gal (Figure 24) and the HydroSeeder with a distributor tank capacity of 1,321 gal (Figure 25) were used to apply the $MgCl_2$. The distributor tanks were loaded utilizing the positive displacement pump mounted on the front of another Mercedes Unimog to suction the brine solution from the railroad tank cars

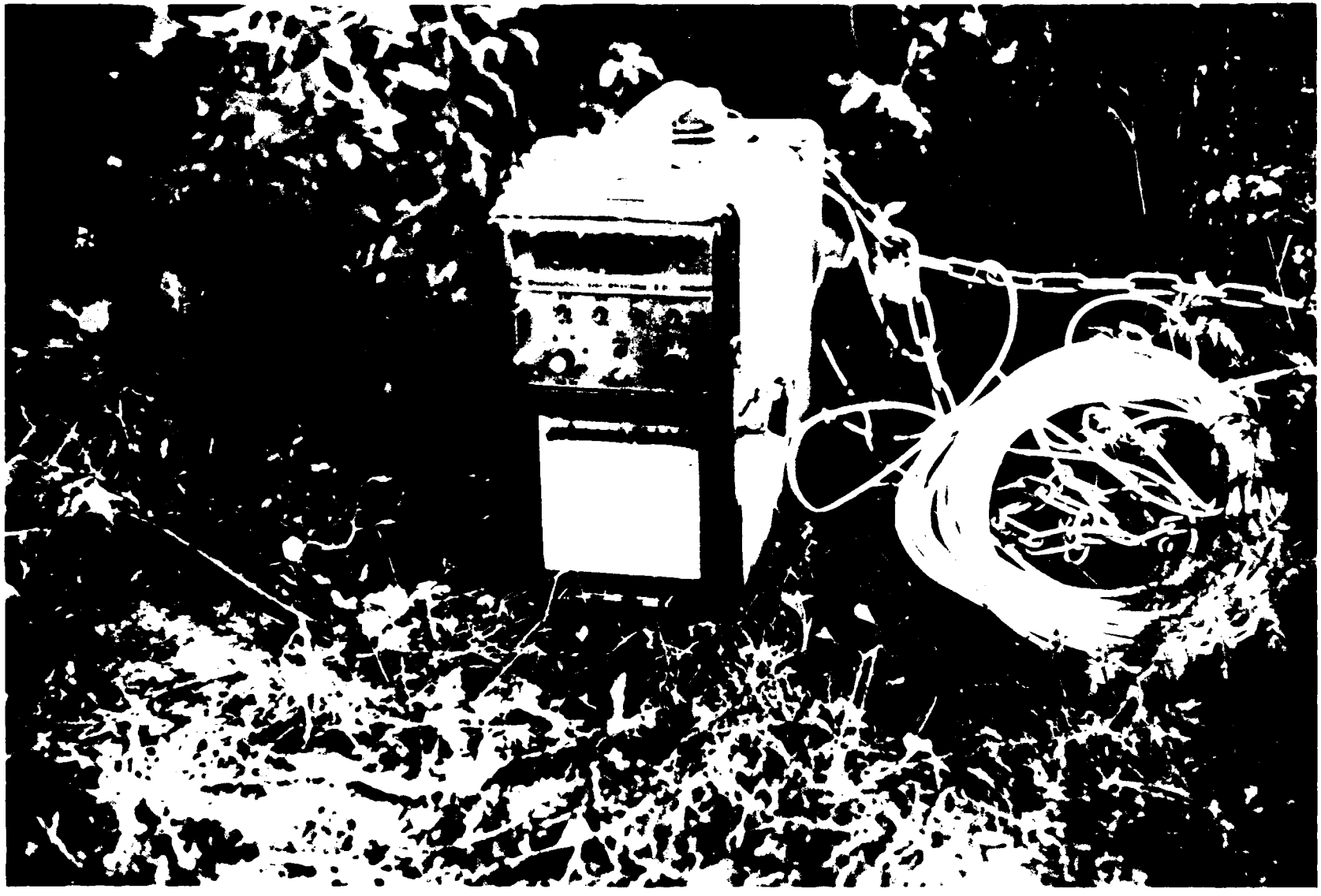

Figure 22. Conductivity meter used to measure increase/decrease of salt ions in stream runoff

Figure 23. Probe from the conductivity meter in a stream at GTA

Figure 24. Mercedes Unimog, with mounted spray bar and distributor and attachments

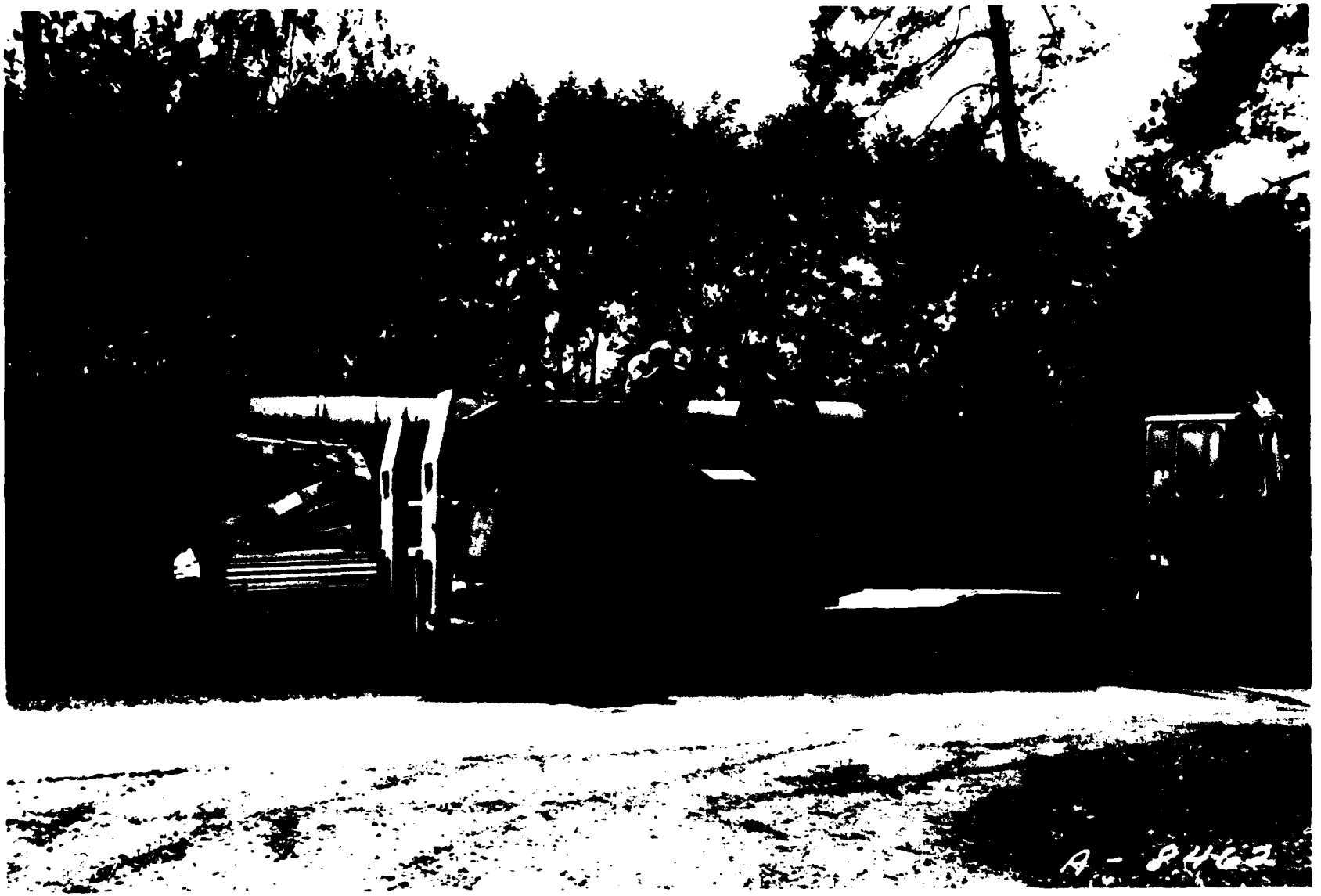

Figure 25. HydroSeeder mounted on a trailer

directly through a flexible hose to the distributor tanks (Figure 26). No special collar device or pump fittings were necessary.

32. The $MgCl_2$ was applied as received at an application rate of not more than 0.50 gal/sq yd. All the dust-control material was applied directly to the selected unsurfaced tank trail area, and none was allowed to run off into adjacent areas or drainage ditches. The Unimog operator and the Hydro-Seeder nozzle operator ensured that there was at least a 6-in. overlap on the previously treated area.

33. The Unimog sprayed the $MgCl_2$ (Figure 27) on the surface of the tank trail at an application rate of 0.156 gal/sq yd. Because of the light spray application (Figure 28), three passes of the Unimog were required to achieve an adequate application rate. The HydroSeeder sprayed the $MgCl_2$ (Figure 29) at an application rate of 0.235 gal/sq yd. Because this spray application (Figure 30) was half of what was required, two passes of the HydroSeeder were required to achieve the necessary application rate on the tank trail surface.

34. Since military mechanized and wheeled vehicle traffic was constant on the treated demonstration site, rolling the treated area with a pneumatic rubber-tired roller was not necessary. With the high volume of traffic, some degradation of the treated area would occur faster than with a lower volume of traffic.

35. The total area treated at GTA was approximately 58,080 sq yd. $MgCl_2$ was applied in the amount of 27,5000 gal for an overall application rate of 0.47 gal/sq yd, which falls within the recommended application rate of 0.42 to 0.50 gal/sq yd. The cost of the $MgCl_2$ was approximately \$0.38/gal for a treatment expense of approximately \$0.19/sq yd (delivered). The German-produced $MgCl_2$ is comparable with the US-produced product, and it is approximately \$0.02/gal less.

36. The final product was a smooth, well-compacted, and relatively dust-free riding surface (Figures 31 and 32).

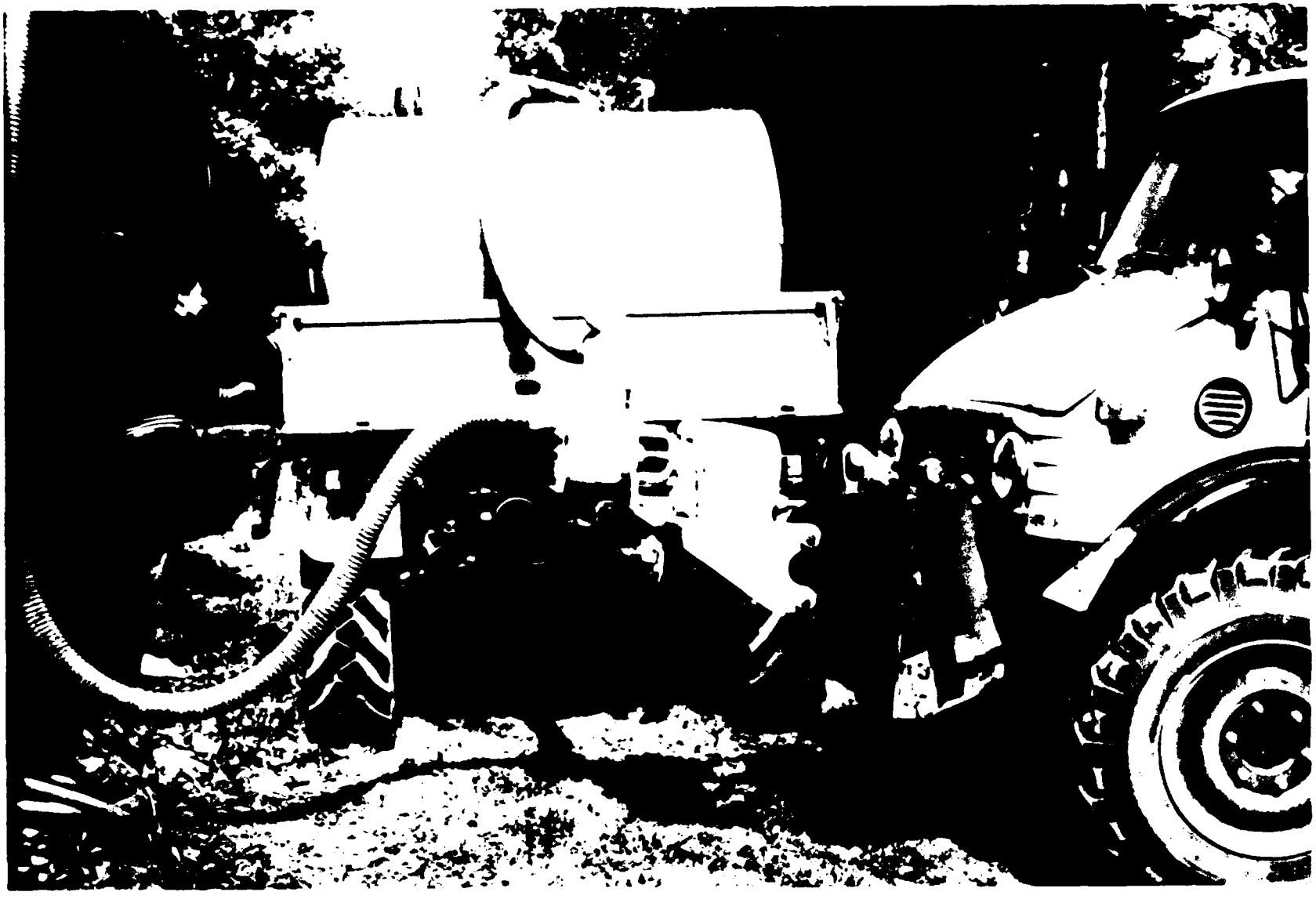

Figure 26. Loading the Unimog distributor using the pump attachment

Figure 27. Unimog distributor in operation

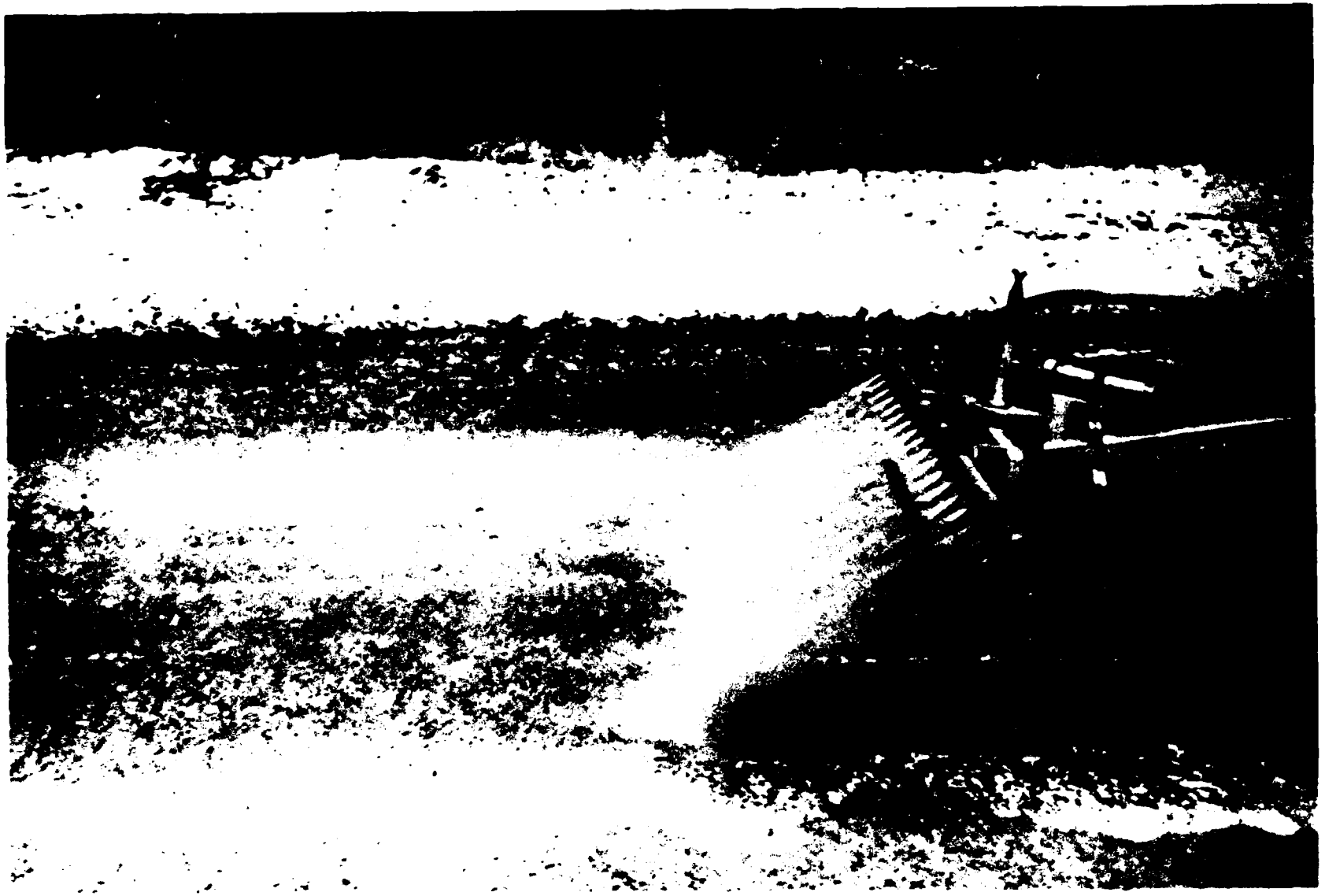

Figure 28. Close-up of fine spray of the Unimog spray bar attachment

Figure 29. Front view of HydroSeeder (in operation) being pulled by Unimog

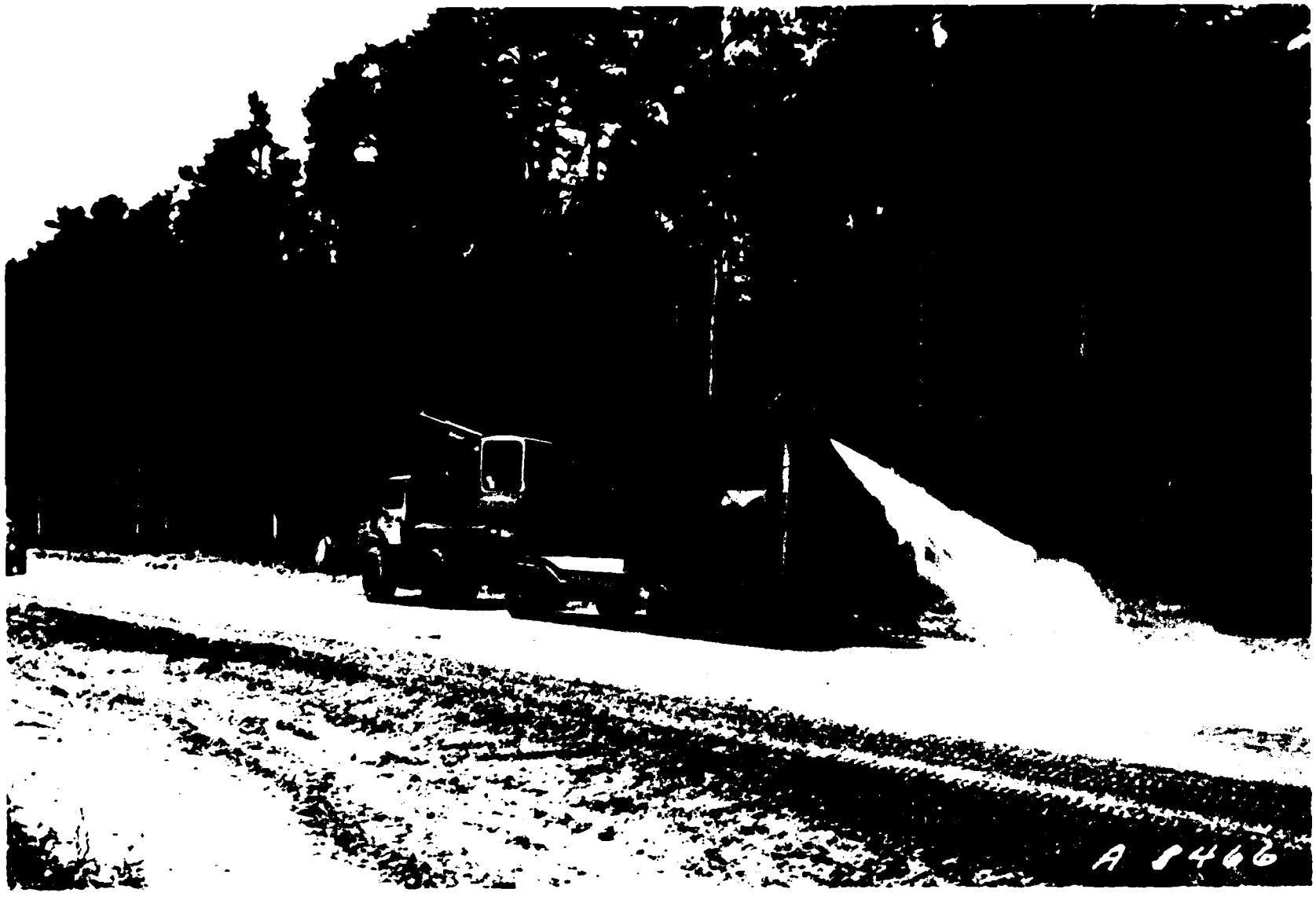

Figure 30. Type of spray by HydroSeeder

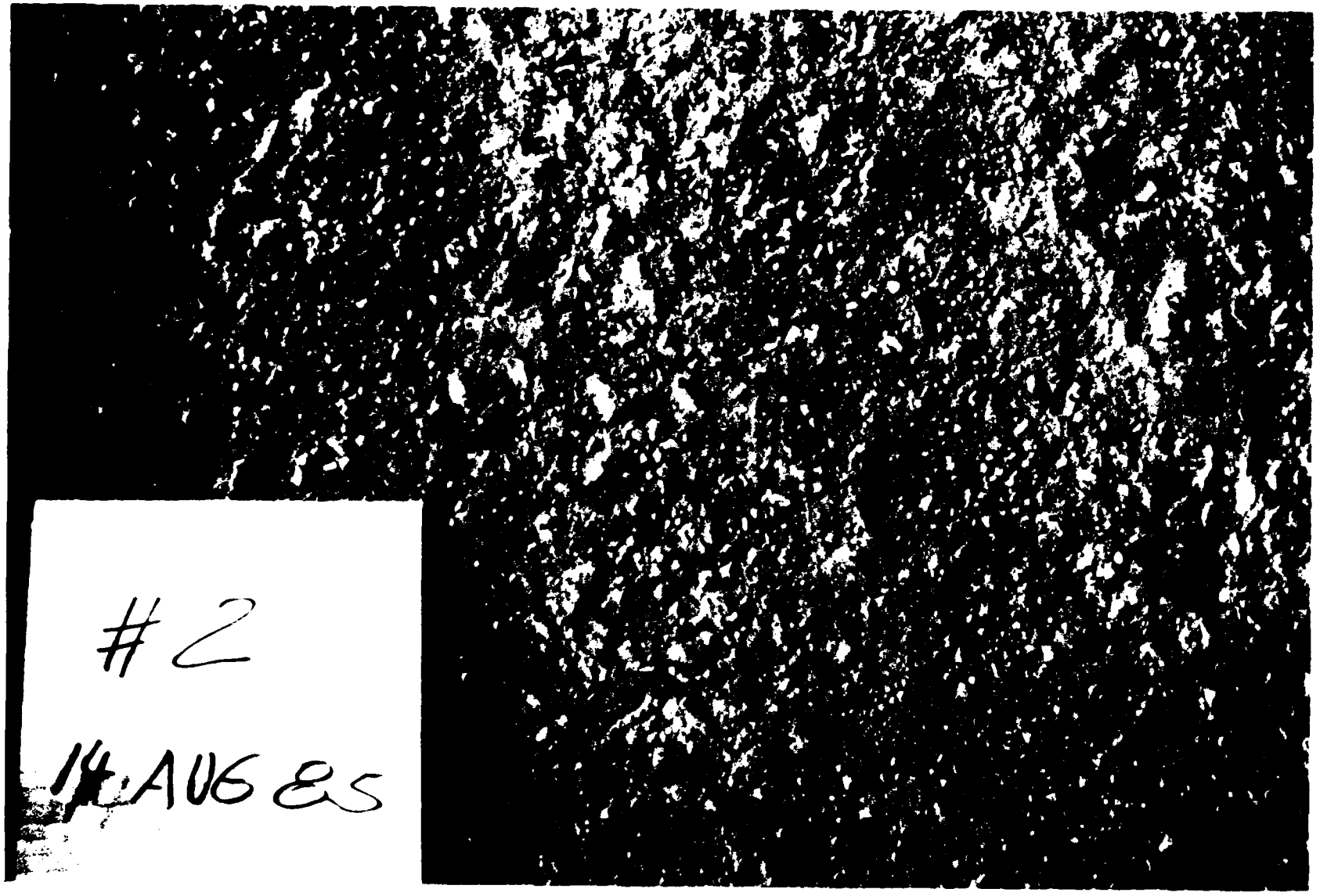

Figure 31. Close-up of basalt section, 2 months after treatment

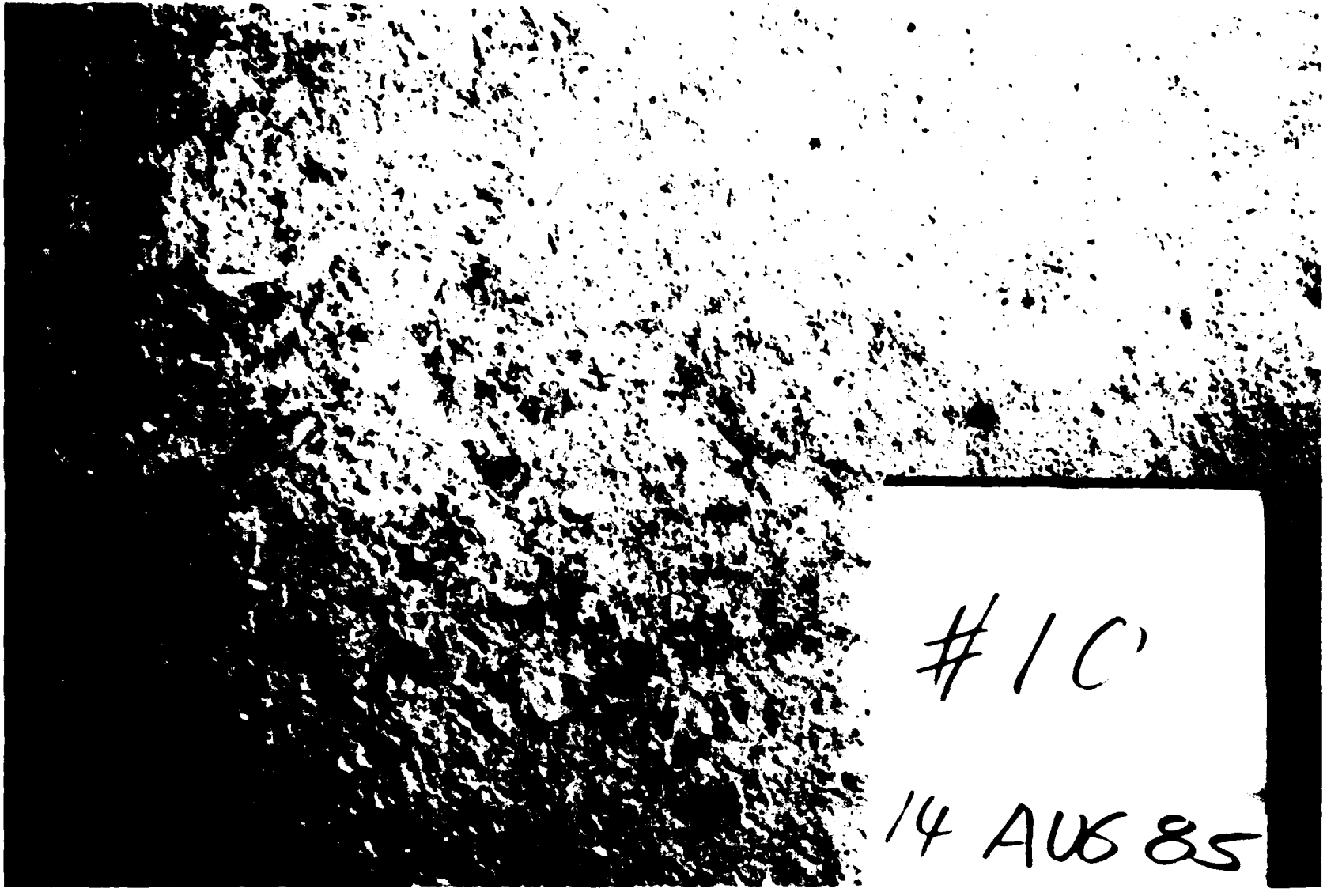

Figure 32. Close-up of limestone section, 2 months after treatment

PART V: KEY FACTORS FOR DUSTPROOFING

37. Key factors recommended for a successful dustproofing project are:

a. Order enough dust-control material for the selected areas to be treated at an application rate of not more than 0.50 gal/sq yd.

b. Plan the project so that equipment and personnel are available to complete the preparation and application procedures in a step-by-step process.

c. Ensure storage facilities for the dust-control material are near the project site.

d. Check to ensure the equipment to be used during the project is in operating order, and accomplish a test run of both the water truck and distributor to verify flow and application rates.

e. Plan to compact the area with a pneumatic rubber-tired roller both before and after treatment (if necessary).

f. Plan to compact the treated area with both a pneumatic rubber-tired roller and a steel-wheeled roller in the nonvibratory mode, if dustproofing an airstrip or helipad.

g. Ensure a 6- to 12-in. overlap of the spray bar on treated sections during application of the dust-control material.

h. Ensure that the commanding officers of units know that vehicles and aircraft that traffic the treated areas should be washed (Figure 33) during the after-operations preventive maintenance period. $MgCl_2$ is a mildly corrosive material.

i. Apply water at approximately 0.10 to 0.20 gal/sq yd to reactivate the $MgCl_2$ if there is an extended period of little or no rainfall or periods of humidity less than 30 percent. Periodic watering (about once or twice a month) during the dry period should be sufficient.

j. Lubricate the pump twice a day to ensure proper operation of the mechanism; flush and lubricate at the end of the project. The modification to an asphalt distributor costs approximately $200. The schematic shown in Figure 14 indicates the modifications to the pump for external lubrication.

k. Provide dust control with $MgCl_2$ on the areas treated for approximately 8 to 12 months with minimal maintenance. The duration of dust control will depend on the type and amount of actual traffic and the weather extremes experienced over the treated areas.

l. Over-spray $MgCl_2$ with more $MgCl_2$ if required. Succeeding treatments are placed at an application rate of 0.25 to 0.30 gal/sq yd. Some buildup or accumulation of the dust-control material will occur in the treated area resulting in longer periods of dust-control effectiveness.

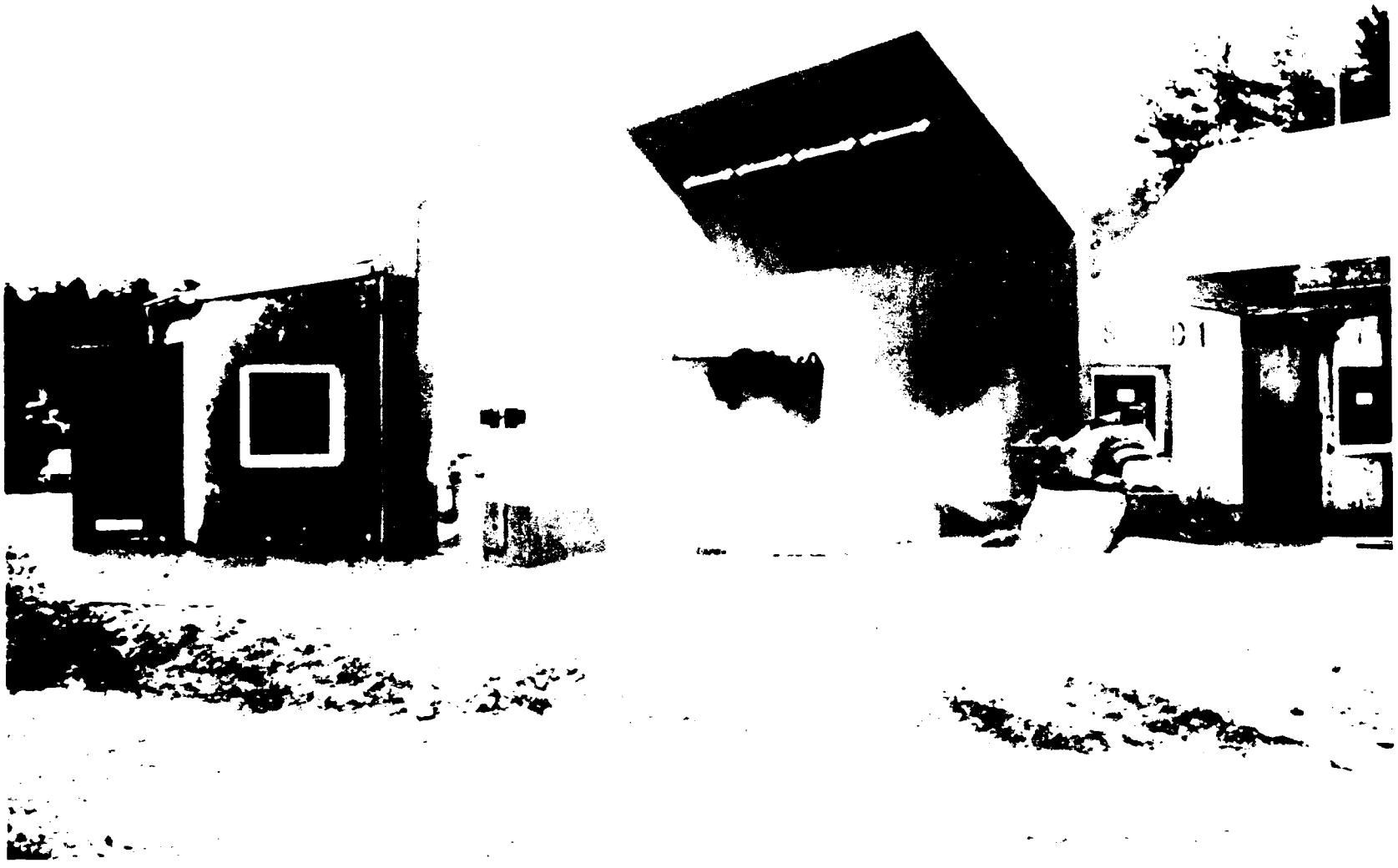

Figure 33. APC being washed after trafficking $MgCl_2$-treated area

PART VI: ECONOMICS

38. $MgCl_2$ is the most economically known product for controlling dust from tracked vehicles on cohesionless (sand and gravel) soils. It is not effective on totally fine-grained soils. Product $MgCl_2$ will leach with rainfall, and in the southeast United States, the effectiveness of a 0.5-gal/sq-yd application is reduced approximately 50 percent following a year's annual rainfall (50 to 60 in.). In the southwest United States, the effectiveness of the same application rate as the southeast United States is reduced approximately 50 percent following 4 months of low humidity (humidity less than 30 percent).

39. The design life of $MgCl_2$ is greatly enhanced when effort is directed to compacting the surface before treatment. $MgCl_2$ imparts little strength to the overall pavement structure.

40. Evidence exists that $MgCl_2$-treated areas benefit from successive treatments and from periodic maintenance (watering).

41. The cost of the material and the amount of time to apply the $MgCl_2$ are minimal; however, with GTA's 1,540 treatable tank trail miles, it would not be economical to dust-control the total length of the tank trails.

42. An advantageous and economical solution to GTA's problem of dust would be to selectively treat (a) sections of tank trails causing the most nuisance to local German communities, (b) the tank firing courses, and (c) the tank trails that run adjacent to the cantonment and bivouac areas. The intangible benefits of better community relations, increased soldier morale, decreased safety hazards, and more realistic tank firing courses could outweigh the cost of purchasing and applying $MgCl_2$.

PART VII: ADVANTAGES AND DISADVANTAGES

43. Reduction in the migration of the fine materials in the surface of an unsurfaced pavement (i.e. controlling dust) will reduce the formation of ruts caused when sufficient fines are displaced to render the larger particles unstable. By limiting the instability of the fine material and postponing the formation of ruts, the need for blading, compacting, and so forth, is substantially decreased resulting in lower maintenance costs. Actual dollar savings will vary with location and weather extremes. During a previous demonstration project utilizing $MgCl_2$, blading of the treated project site was reduced from 12 to 4 times a year at the installation (Styron, Hass, and Kelley 1985).

44. $MgCl_2$ has received limited evaluation as to its environmental influence. The practice of spraying the material with a controlled spray bar height above the roadway and ensuring the material is sprayed only on the roadbed with no runoff permitted provides an environmentally acceptable procedure and product. $MgCl_2$ is known to leach out of the treated material with time; however, a long time and considerable rainfall is required (Styron and Spivey 1982, Houston 1983).

45. A dust-controlled surface is not designed in the same sense as engineering projects. A dustproofing material is selected depending on the cost, type of traffic, soil type, and weather extremes. The material is applied at a rate that avoids all runoff and does not exceed 0.50 gal/sq yd. Maintenance or additional applications are scheduled as required depending on actual use and existing weather conditions. A combined Army and Air Force dust-control manual exists for assistance (Headquarters, Departments of Army and Air Force 1974).

46. $MgCl_2$ provides a finite period of dust control on unsurfaced pavement structures which improves vehicle operator safety, improves aircraft landing visibility, substantially increases flight operations, and decreases the dust signature of vehicles and aircraft.

47. The local German Water Control Board Report measured the amount of salt ions in the stream adjacent to the demonstration site. The report (Appendix B) identified the measured amount of salt ions before, during, and after the application of $MgCl_2$. The Water Control Board stated that $MgCl_2$ is no more environmentally harmful than road salt.

48. Approximately 4 months after application of the $MgCl_2$, the demonstration site was bladed and regravelled. The effectiveness of dust control was approximately 60 percent. During the 4 months of existence of the $MgCl_2$, there was a 70 percent reduction in blading and regravelling, and tank-trail maintenance was minimal on the project site which compared to blading and maintenance of at least twice a month prior to treatment. The reasons for blading and maintenance (as given by the DEH, 7^{th}ATC) were that the heavy volume of mechanized and tank traffic had pulverized the gravel, the $MgCl_2$ was losing its effectiveness, and regravelling was considered necessary in preparation for the winter-weather cycle.

PART VIII: CONCLUSIONS

49. The application and performance of $MgCl_2$ were demonstrated at Grafenwohr Training Area, Federal Republic of Germany. The method of application, equipment required, and labor necessary to conduct a dust-control project were described and explained. A videotape report was prepared for DOD personnel who were interested in the dustproofing procedures described herein but could not attend the demonstration. The attendees observed $MgCl_2$ controlling dust and took note of the advantages and disadvantages of $MgCl_2$, including cost.

50. $MgCl_2$ is a viable dustproofing material that should be considered for use on military unsurfaced roads and airstrips.

51. Various types of equipment can be used to apply $MgCl_2$. At this demonstration, a Mercedes Unimog was used to apply the brine solution, but it had to be flushed after every other load of $MgCl_2$ was sprayed. Also, the capacity of the distributor tank was too small for the large demonstration section, but would be good for small areas such as an unsurfaced parking lot. The HydroSeeder was excellent as a distributor for the $MgCl_2$. It completed in 1 hr an area that the Unimog accomplished in 1 day. With the use of the HydroSeeder, the nozzle operator had to make sure he applied the $MgCl_2$ on the roadbed very carefully because of the height of the nozzle above the unpaved surface.

PART IX: RECOMMENDATIONS

52. During this demonstration, the $MgCl_2$-treated sections provided a relatively dust-free, unpaved riding surface (Figures 34 and 35). The lack of clouds of dust and suspended dust could result in less wear and tear on engines, turbines, and sensitive mounted equipment in vehicles. The dollar savings could be substantial in the long term.

53. Vehicle signatures (suspended dust and dust clouds) provide an enemy with recognizable indications of vehicle movements in a tactical scenario. $MgCl_2$ could provide a finite period of dust control in rear-area operations that might have an overall impact on the battlefield and provide the surprise and tactical supremacy at a given point in time.

54. This demonstration has utilized $MgCl_2$ in the brine-solution form; however, $MgCl_2$ is also produced in the dry form (pellet or snowflake). In the dry form, it has been used in the northern US tier states as a road deicer. This dry form may be an acceptable bulk material for dust control if applied on unsurfaced roads like a fertilizer, disked into the roadbed, and then over-sprayed with water.

55. Four key recommendations needed for future studies have been identified as follows:

a. An equipment impact study to determine the net result of $MgCl_2$ in the reduction of wear and tear on vehicles.

b. A study to indicate the decreased vehicle signatures utilizing $MgCl_2$ on unsurfaced roads.

c. A study to determine the procedure and application of dust-control materials in dry form.

d. A cost-impact study to determine the cost savings, both tangible and intangible, that could be derived from utilizing $MgCl_2$ on unsurfaced roads.

Figure 34. $MgCl_2$ is approximately 75 to 80 percent effective after 2 months of traffic and weathering

Figure 35. Minimal amount of dust generated by military vehicle 2 months after treatment with $MgCl_2$

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APPENDIX A: MAGNESIUM CHLORIDE ($MgCl_2$) FOR DUST CONTROL OF TANK TRAILS

Literature Search

1. A comprehensive literature search (Toxline, Medline, Chemline, Hazard Line, Biological Abstracts, Toxic Data Bank, and other available sources) was made for "The Potential Long-Term Effects on the Water Table and Vegetation Caused by the Use of $MgCl_2$ for Dust Control." There appears to be no reported evidence that $MgCl_2$ has had or will produce any effects on the ground water, the water table, or on vegetation following single or repeated applications to soil.

2. $MgCl_2$ has extensive industrial uses (e.g., fire extinguishers, fireproofing wood, casein glue, floor-sweeping compounds) and is not a toxic compound (Patty's Industrial Hygiene and Toxicology, Vol 2A Toxicology 1981)*. The LD_{50} in rats (lowest lethal dose for 50 percent of the tested animals) is reported as 2.8 g/kg of body weight (Registry of Toxic Effects of Chemical Substances (RECTS), 1981-82, Vol 2 1983). The compound appears to be free from any adverse toxicity in both experimental animals (Registry of Toxic Effects of Chemical Substances (RECTS), 1981-82, Vol 2 1983) and in fish (Miller and Landesman 1978; Woodward 1983). It has been evaluated for potential mutagenicity in the mouse-lymphoma bioassay and found to be negative (Oberly, Piper, and McDonald 1982). Only one report was found for the possible effects of $MgCl_2$ on vegetation: $MgCl_2$ was studied for its effects on pollen viability and found to have no specific effects (Ready and Goss 1971).

3. Only one analysis for other heavy metals in $MgCl_2$ was found. This is given as Appendix A in Styron and Spivey (1982). The minor toxic metals (As, Zn, Cu, Ni) were found to be present at not more than 1 ppm (Table A1). There are no US Army Military Specifications.

Summary

4. The possible effects of $MgCl_2$ use in road dust control on water and vegetation were investigated. No toxicological effects have been reported for $MgCl_2$, and one report of trace metal contaminants indicates no impact on its toxicity.

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* All references cited in this Appendix are included in the References at the end of the main text.

Table A1

$MgCl_2$ Product Specifications

Chemical		
Major Constituents	Typical Analysis*, Percent	Limits (Minimum/Maximum)
$MgCl_2$	32.0	28 35
SO_4	2.5	+1
K	0.3	--
Na	0.3	--
Ca	0.05	--
Water	Varies	--
Total	100.00 percent	

Minor Elements	Typical Analysis*
Li	600 ppm
B	500 ppm
Br	900 ppm
Fe	> 1 ppm
Ni	> 1 ppm
Cu	> 1 ppm
Zn	> 1 ppm
As	> 0.5 ppm

Physical

1 gal = 10.8 lb**

sp gr = 1.30 ± 0.05

Viscosity = 5 cps @ 77°F

* Weight brine basis (a standard identification test procedure).

** A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3 of the main text.

APPENDIX B: DUST CONTROL WITH MAGNESIUM CHLORIDE, WEIDEN WATER CONTROL BOARD REPORT

Wasserwirtschaftsamt Weiden

Wasserwirtschaftsamt Gabelsbergerstraße 2, 8480 Weiden i. d. OPf.

Directorate of Engineering
and Housing
Environmental Branch
Gebäude 433
Lager Grafenwöhr

8484 Grafenwöhr

Ihre Zeichen	Ihre Nachricht vom	Bitte bei Antwort angeben Unser Zeichen	☎ (09 61) 3 04- Zimmer Nr	Weiden
-	-	A 2-4428.NEW/Gr - 342	Labor: 34330/Müller oder 3 04 - 0	17.02.1986

Dust Control mit Magnesiumchlorid

Anlage
Abschlußbericht

Sehr geehrte Damen und Herren,

als Anlage erhalten Sie den gewünschten und versprochenen Abschlußbericht. Wir bitten die zeitliche Verzögerung zu entschuldigen. Aufgrund personeller Engpässe im Sachgebiet Gewässergüte konnte der Bericht erst jetzt abgefaßt werden.

Mit freundlichen Grüßen
I.A.

Müller

Müller

Dienstgebäude
Gabelsbergerstraße 2
Weiden

Besuchszeiten
Mo - Do 8.00 - 11.30 Uhr
13.30 - 15.30 Uhr
Fr 8.00 - 11.30 Uhr
13.30 - 15.00 Uhr

Telex
63 867

Konto der Zahlstelle
Stadtsparkasse Weiden
Nr. 172 809 (BLZ 753 500 00)

A 2 - 4428.NEW/Gr - 342 Weiden, 17.02.1986

Dust Control mit Magnesiumchlorid

Magnesiumchlorid wurde zwischen Juni/Juli 1985 auf einer Teststrecke zum Zwecke der Staubfreimachung auf Panzerstraßen angewendet.

Das Versuchsgebiet umfaßte den Einzugsbereich der Vorfluter Schaum- und Thumbach

1. Aufgabenstellung

- Zu prüfen war der Einfluß von Magnesiumchlorid auf die beiden Oberflächengewässer

- Errichtung von Meßstellen zur kontinuierlichen, registrierenden Messung der Leitfähigkeit am:

  · Thumbach an der Truppenübungsplatzgrenze (UTMREF 083117)

  · Schaumbach, Waschplatz B (UTMREF 091099)

- Zeitraum der Aufzeichnungen: 14. bzw. 18.6. bis 12.07.1985

- Entnahme von Gewässerproben (siehe Anlagen)

2. Bewertung der Meßergebnisse

Thumbach

- Die Leitfähigkeit (µS/cm) des Thumbaches liegt vor Testbeginn etwa bei 244 µS/cm

- während der Testphase ist in Abhängigkeit von den Niederschlagsereignissen keine Änderung der Leitfähigkeit erkennbar

Schaumbach

- Die Leitfähigkeit (µS/cm) des Schaumbaches liegt vor Testbeginn etwa bei 107 µS/cm

- während der Testphase sind in Abhängigkeit von den Niederschlagsereignissen Änderungen in der Leitfähigkeit aufgetreten

25.06.85:	Anstieg auf 170 µS/cm,	für ca. 2 Stunden gleichbleibend
28.06.85:	Anstieg auf 250 µS/cm,	für ca. 3 Stunden gleichbleibend
01.07.85 - 02.07.85	Anstieg auf 500 µS/cm,	für ca. 8,5 Stunden gleichbleibend

3. Wasserwirtschaftliche Bewertung

- Magnesiumchlorid ($MgCl_2 \cdot 6H_2O$) ist in der EG-Richtlinie vom 04.05.1976 betr. Ableitung gefährlicher Stoffe in die Gewässer nicht genannt.

  Das Magnesium-Ion wirkt in Wasser als Härtebildner; das Chlorid-Ion wirkt wie beim Speisesalz.

  Magnesiumchlorid ist im allgemeinen nicht als wassergefährdender Stoff einzustufen (Wassergefährdungsklasse, WGK 0)

- Eine aktuelle, d.h. zum Zeitpunkt der Niederschlagsereignisse gemessene Konzentration an Mg-chlorid im Gewässer liegt nicht vor. Der temporäre Anstieg der Leitfähigkeit im Schaumbach zeigt zumindest einen Einfluß von Mg-chlorid an, allerdings ist auch der Gesamtanstieg der Leitfähigkeit nicht ausschließlich dem Magnesiumchlorid zuzuordnen, da hierbei auch Abschwemmung des Straßenbefestigungsmaterials mitbeteiligt ist.

- Die Problematik der Mg-chlorid-Anwendung ist in die Gewässerbeeinträchtigung durch Streusalze eingliederbar. U.E. dürfte die Belastung der Gewässer mit Chloriden aus der Dust-Control-Anwendung derzeit kein vorrangiges Problem für den Gewässerschutz darstellen.

  Für den verbreitet zu beobachtenden langfristigen Anstieg des Salzgehaltes von Grundwasser können Versickerungen von Düngesalzen und Abwässern hauptsächlich verantwortlich sein, auch an Auswirkungen von Luftverunreinigungen ist zu denken.

  Bereits aus Gründen eines vorsorglichen Gewässerschutzes sollte bei der Verwendung des naturgemäß wasserlöslichen Magnesiumchlorids nach dem Grundsatz - Soviel wie nötig, sowenig wie möglich - verfahren werden.

  Generell sollten salzhaltige Abwässer von Verkehrsflächen (Panzerstraße) auch wegen der Belastung mit anderen Schmutzstoffen nicht in besonders empfindliche Bereiche wie Trinkwasserschutzgebiete, kleinere stehende Gewasser oder natürliche Feuchtbiotope eingebracht werden. Grundwasserbelastungen können durch Vermeidung punktförmiger Einleitungen bzw. Versickerungen möglichst gering gehalten werden.

Wasserwirtschaftsamt
Weiden
I.A.
Müller
Müller

Schaumbach, Waschplatz B

	Nullproben		Proben aus Versuchszeitraum *		
Datum	29.05.85	14.06.85	21.06.85	26.06.85	05.07.85
Uhrzeit	14.30	15.15	14.55	14.40	11.00
TW	18,5	15,8	14,3	16,3	18,5
pH Labor	8,4	7,5	7,4	7,5	7,7
LF Feld	108	98	91	92	88
LF Labor	116	98	-	-	-
Cl (mg/l)	5	2	-	-	-
SO_4 (mg/l)	15	8	-	-	-
GH (°dH)	3,0	2,5	2,5	2,4	2,9
Ca (mg/l)	22,8	12,4	11,6	11,2	11,6
Mg (mg/l)	3,9	3,3	3,3	3,4	2,9

* ohne Niederschlagsereignisse

Thumbach, Übungsplatzgrenze

	Nullproben		Proben aus Versuchszeitraum *		
Datum	29.05.85	14.06.85	21.06.85	26.06.85	05.07.85
Uhrzeit	15.15	16.15	14.00	14.25	10.15
TW	14,8	13,8	11,6	12,9	15,1
pH Labor	7,7	7,8	7,6	7,7	7,7
LF Feld	246	251	256	255	264
LF Labor	253	255	-	-	-
Cl (mg/l)	35	12	-	-	-
SO_4 (mg/l)	20	14	-	-	-
GH (°dH)	6,9	7,2	7,3	7,1	7,7
Ca (mg/l)	48,2	42,5	43,5	42,7	43,7
Mg (mg/l)	1,5	4,6	4,0	4,0	6,1

* ohne Niederschlagsereignisse

TRANSLATION/UEBERSETZUNG

Wasserwirtschaftsamt Weiden
Gabelsbergerstr. 2
8480 Weiden i. d. Opf.

17 February 1986

Directorate of Engineering and Housing
Environmental Branch
Bldg 433
8484 Grafenwoehr-Lager

SUBJECT: Dust Control with Magnesium Chloride

Enclosure: Final Report

Ladies and Gentlemen,
enclosed we forward the requested and promised final report. Please excuse the delay. Because of a shortage in personnel at our Water Quality Section we were not able to do the report earlier.

Sincerely yours

In Proxy

s/t Mueller

A2-4428.NEW/Gr-342

Dust Control With Magnesium Chloride

During June/July 1985 magnesium chloride was applied on a test section of the tank trail for the purpose of dust control.

The test stretch included the catchment area of the receiving streams Schaumbach and Thumbach.

1. Problem Definition

- The influence of magnesium chloride on the two surface waters had to be investigated.

- Erection of metering points for continuous recording measurements of the conductivity of:

o the Thumbach at the boundary of the training area (UTMREF 083117)

o the Schaumbach, washrack B (UTMREF 091099)

- Period of recordings: 14 and 18 June through 12 July 1985.

- Water samples taken (see enclosure)

2. Evaluation of Metering Results

Thumbach

- The conductivity (µS/cm) of the Thumbach prior to start of test is appr. 244 us/cm

- During the test period no change of conductivity in dependence of precipitations is observed.

Schaumbach

- The conductivity (µS/cm) of the Schaumbach prior to start of test is appr. 107 µS/cm.

- During the test period changes of conductivity in dependence of precipitations occurred.

25 June 85: Increase to 170 µS/cm, for about 2 hours unchanged

26 June 85: Increase to 250 µS/cm, for about 3 hours unchanged

1 July 85: Increase to 500 µS/cm, for about 8.5 hours unchanged
2 July 85

3. Water Quality Evaluation

- Magnesium chloride (Mg CL_2 x 64_2 O) is not mentioned in the European Guidelines, dated 4 May 1976, regarding the discharge of dangerous substances into waters.

The magnesium - ion acts in water as hardness forming agent; the chloride-ion acts the same as in table-salt.

Generally magnesium chloride is not classified as a water endangering substance (water endangering class 0)

- A realistic measured concentration of Mg-chloride in water at the time of precipitation is not available. The temporary increase of conductivity is not only caused by magnesium chloride, because also washed off materials from the road pavements are involved.

- The use of Mg-chloride can be classified in the category of water impairment by de-icing salt. The strain of waters with chloride from dust control measures presently does not constitute a primary problem for water protection.

The widespread long term increase of salt content in ground waters may mainly be caused by seepages of fertilizing salts and waste waters, also air polluting effects must be considered. But for reasons of a preventive water protection the use of this water soluble magnesium chloride should be made according to the principle procedure - as much as necessary - as little as possible.

In general, salt containing waste waters from traffic areas (tank trail) should no be discharged into sensitive terrains like water protection areas, small stagnant waters or natural wet biotopes, also because of the strain caused by other pollutants. Ground water strains can be kept to a minimum by avoiding concentrated discharges and seepages, respectively.

Water Control Office
Weiden
(In Proxy)

s/t Mueller

Schaumbach, Washrack B

	Samples prior to test		Samples during * test period		
Date	29.05.85	14.06.85	21.06.85	26.06.85	05.07.85
Time	14.30	15.15	14.55	14.40	11.00
TW	18,5	15,8	14,3	16,3	18,5
pH Laboratory	8,4	7,5	7,4	7,5	7,7
LF Field	108	98	91	92	88
LF Laboratory	116	98	-	-	-
Cl (mg/l)	5	2	-	-	-
SO_4 (mg/l)	15	8	-	-	-
GH (^{o}dH)	3,0	2,5	2,5	2,4	2,9
Ca (mg/l)	22,8	12,4	11,6	11,2	11,6
Mg (mg/l)	3,9	3,3	3,3	3,4	2,9

* Without Precipitation

Thumbach, Boundary of Training Area

	Samples prior to test		Samples during * test period		
Date	29.05.85	14.06.85	21.06.85	26.06.85	05.07.85
Time	15.15	16.15	14.00	14.25	10.15
TW	14,8	13,8	11,6	12,9	15,1
pH Laboratory	7,7	7,8	7,6	7,7	7,7
LF Field	246	251	256	255	264
LF Laboratory	253	255	-	-	-
Cl (mg/l)	35	12	-	-	-
SO_4 (mg/l)	20	14	-	-	-
GH (^odH)	6,9	7,2	7,3	7,1	7,7
Ca (mg/l)	48,2	42,5	43,5	42,7	43,7
Mg (mg/l)	1,5	4,6	4,0	4,0	6,1

* Without Precipitation

END

4-87

DTIC